

TITLE PAGE

(UFP-QAPP Manual Section 2.1 and UFP-QAPP Workbook Worksheet [WS] #1)

Final

Navy Tier II Sampling and Analysis Plan

Remedial Investigation

Site 69 – Building 1018 (Oxidizer Process Building)

Naval Support Facility Indian Head Indian Head, Maryland

Prepared for:

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EXECUTIVE SUMMARY

This Uniform Federal Policy (UFP) Sampling and Analysis Plan (SAP) (Navy "Tier 2" format) was prepared for Naval Facilities Engineering Command (NAVFAC) Washington by KOMAN Government Solutions, LLC (KGS) and Tetra Tech, Inc. under Contract No. N40080-12-D-0451, Task Order (TO) 10. This SAP provides the site-and project-specific work plan components for a Remedial Investigation (RI) at *Site 69 – Building 1018 (Oxidizer Process Building)* (referred to herein as the site), Naval Support Facility Indian Head (NSFIH), Indian Head, Maryland. The project-specific Health and Safety Plan (HASP) and the NSFIH Master UFP-SAP (Tt, 2009) will accompany this project-specific SAP in the field.

The RI is being performed by the Navy (lead agency) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulatory framework in accordance with the *Federal Facility Agreement for NSFIH* (Navy, 2000). This RI SAP is effectively an addendum to the *SAP for the Site Screening Process (SSP) Investigation at Site 69* (Tetra Tech, 2013); however, this RI SAP was prepared to be a standalone to document.

Site 69 is located in the center of the Main Area of the facility (Figure 2), with an approximate site boundary extending from former Building 1018 (source area) to Town Gut Creek and measuring more than 9 acres (Figure 3). The site topography slopes steeply from former Building 1018 (30 feet [ft] above mean sea level [msl]) to the Creek (5 ft msl) (Figure 4). The site contains many buildings, elevated walkways, and access roads associated with perchlorate processing and storage. Otherwise, the ground surface is mostly grassed with some eroded drainage paths, some small creeks and grassed drainage swales, and several concrete-lined channels leading to Town Gut Creek. The loading dock at Building 1018 was the initial transfer location for perchlorate grains being processed at the facility. The building was used for the grinding of ammonium perchlorate and potassium perchlorate into powder form, and the interior was washed out periodically onto the surrounding ground surface.

The Navy demolished and removed Building 1018 and all its associated structures/features (e.g., hydraulic lift and loading dock) in 2012. Sampling to support the demolishment activities revealed elevated levels of perchlorate in the soil and standing water in the vicinity. The IHIRT agreed to utilize the SSP to evaluate perchlorate contamination in the area presumably from past loading spills and subsequent washing of the building floor, loading and spill area. Building 1018 was the only area with hazardous material handling, and an SSP Investigation identified perchlorate in subsurface soil and groundwater above human health screening levels for soil and tap water in samples proximate to the source area (Tetra Tech, 2015). Perchlorate was not detected in sediment samples, but surface water exceeded the tap water screening level for human health. The screening human health risk assessment in the SSP Investigation Report indicated a noncancer Hazard Index (HI) above 1 for exposure to perchlorate in subsurface soil and groundwater. The screening ecological risk assessment in the report indicated no unacceptable ecological risk to receptors exposed to perchlorate in surface soil, sediment, or surface water.

The following objectives for the Site 69 RI are identified by the Indian Head Installation Restoration Team (IHIRT), which comprises the Navy (or NAVFAC), U.S. Environmental Protection (USEPA) Agency Region 3, Maryland Department of the Environment (MDE), and NSFIH:

- Delineate perchlorate contamination in site soil and groundwater
- Determine extent of perchlorate source area near former Building 1018
- Determine extent of perchlorate contamination in surface water
- Complete a baseline human health risk assessment (HHRA)

Determine if further response action is necessary at Site 69 and/or downgradient of the site

Meeting these objectives and completing the RI investigation fieldwork will require several field tasks and the use of multiple subcontractors as described throughout this SAP. Field tasks include the following: utility clearance, soil borings, monitoring well installations, monitoring well groundwater sampling, surface and subsurface soil sampling, sediment and surface water sampling, surveying, management of investigation-derived waste (IDW), decontamination activities, and other related, ancillary tasks. The following subcontractors will be required to complete the RI investigation: utility clearance, drilling / direct push technology (DPT), survey, IDW management, and offsite laboratory services. Following offsite laboratory analysis of the various samples, the data will be validated, evaluated, and presented in the RI Report. The RI Report will be prepared consistent with Navy and EPA guidance and recent RI reports for NSFIH.

Data Quality Objectives (DQOs) are identified or developed herein, including decision action limits and risk-based screening levels for perchlorate. Samples in all applicable media will be analyzed for perchlorate, which was selected based on the findings and conclusions of the SSP Investigation Report, as well as previous research on past and current site operations. Other parameters and analyses detailed in this SAP will support the human health risk assessment and an evaluation of site geochemical conditions. In addition, groundwater will be tested for microbial genetic material indicative of conditions favorable for perchlorate biodegradation.

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Sections in this document correspond to Navy Tier 2 SAP Section numbers as amended by KGS and/or Tetra Tech. Sections consisting of tabular content (corresponding to SAP worksheet content) are not listed as individual tables in the Table of Contents. For formatting purposes, even-numbered pages at the end of a section may be blank such that the next section starts on an odd-numbered page. Any purposeful blank page is labeled as such. Figures are located at the end of the document. Appendices are provided electronically, only. The entire document is provided as a bookmarked Portable Document Format (PDF) file on the accompanying disc. All references are available for review in the Administrative Record for Naval Support Facility Indian Head.

APPENDICES

- A Historical Information
- B Fieldwork Standard Operating Procedures (SOPs)
- C Laboratory Department of Defense (DoD) Environmental Laboratory Accreditation Process (ELAP) Certifications

FIGURES

- 1 Facility Location
- 2 Site Location
- 3 Site Plan Aerial
- 4 Site Plan Topography
- 5 Interpretive Three-Dimensional Conceptual Site Model
- 6 Human Health Exposure Pathway Analysis
- 7 Proposed RI Sample Locations

ACRONYMS AND ABBREVIATIONS

about or approximately

number % percent

%D percent difference
 ± plus or minus
 °C degree Celsius
 °F degree Fahrenheit

< less than > greater than µg microgram(s)

μg/kg microgram(s) per kilogram μg/L microgram(s) per liter μm micron(s) or micrometer(s)

a.k.a. also known as AOC Area of Concern

bgs below ground surface

c/o care of

CAS Chemical Abstract Service [Number]

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act of 1980

CFR Code of Federal Regulations

CLEAN Comprehensive Long-Term Environmental Action Navy

CLP Contract Laboratory Program CoC chain-of-custody [form]

COPC Chemical of Potential Concern

COPEC Chemical of Potential Ecological Concern

CSM Conceptual Site Model CTO Contract Task Order

CVAA Cold Vapor Atomic Absorption

DAF Dilution Attenuation Factor

DL Detection Limit

DoD Department of Defense
DNAPL dense non-aqueous phase liquid

DO dissolved oxygen

DOC dissolved [total] organic carbon

DPT Direct Push Technology (a.k.a. Geoprobe®)

DQI Data Quality Indicator
DQO Data Quality Objective
DVM Data Validation Manager

eco ecological

EDD electronic data deliverable

ELAP [DoD] Environmental Laboratory Accreditation Program

EPA U.S. Environmental Protection Agency

EPC exposure point concentration ERA ecological risk assessment

ERP [Navy] Environmental Restoration Program

ESTCP Environmental Security Technology Certification Program

FCR Field Change Request FFA Federal Facility Agreement FID flame ionization detector FOL Field Operations Leader

FS Feasibility Study ft feet or foot

FTMR Field Task Modification Request

g gram(s)

GPS Global Positioning System

H&S H&S Environmental, Inc.
HASP Health and Safety Plan

HHRA human health risk assessment

HQ Hazard Quotient

HPLC High Pressure Liquid Chromatograph

HSA hollow stem auger

IC Ion Chromatograph
ICAL initial calibration
ICB initial calibration blank
ICP Inductively Coupled Plasma
ICS Interference Check Sample
ICV Initial Calibration Verification

ID identification

IDW investigation-derived waste

IHIRT Indian Head Installation Restoration Team

ILCR Incremental Lifetime Cancer Risk IRP [Navy] Installation Restoration Program

IS Internal Standard

ITRC Interstate Technology and Regulatory Council

kg kilogram(s)

KGS KOMAN Government Solutions, LLC

L liter(s)

LC liquid chromatography
LFB Laboratory Fortified Blank

LIMS Laboratory Information Management Systems

LOD Limit of Detection
LOQ Limit of Quantification

MCL [federal] Maximum Contaminant Level

MCT Matrix Conductivity Threshold

MDE Maryland Department of Environment

MDL Method Detection Limit

mg milligram(s)

mg/kg milligram(s) per kilogram mg/L milligram(s) per liter

mL milliliter(s)

MNA monitored natural attenuation
MPC Measurement Performance Criteria
MQO Measurement Quality Objectives

MS mass spectrometry
MS Matrix Spike

MSD Matrix Spike Duplicate msl [above] mean sea level

NA or N/A not applicable

NAD North American Datum

NAVFAC Naval Facilities Engineering Command NEDD NIRIS Electronic Data Deliverable

NIRIS Navy Installation Restoration Information Solution

No. number

NSF Naval Support Facility

NSFIH Naval Support Facility Indian Head NTU Nephelometric Turbidity Unit

ORNL Oak Ridge National Laboratory
ORP oxidation-reduction potential

OSHA Occupational Safety and Health Administration
OSWER Office of Solid Waste and Emergency and Response

oz ounce(s)

PAL Project Action Limit

PARCC Precision, Accuracy, Representativeness, Completeness, and Comparability

PDF Portable Document Format
P.E. Professional Engineer
P.G. Professional Geologist
PID photoionization detector

PM Project Manager

PPE personal protective equipment
PQL Project Quantitation Limit
PQLG Project Quantitation Limit Goal
PQO Project Quality Objective

PRQL Project-Required Quantitation Limit

PSL Project Screening Limit PVC polyvinyl chloride

QA Quality Assurance

QAM Quality Assurance Manager
QAO Quality Assurance Officer
QAPP Quality Assurance Project Plan

QC Quality Control
QL Quantitation Limit
QS Quality System

QSM Quality Systems Manual

RAGS [U.S. EPA] Risk Assessment Guidance for Superfund

RI Remedial Investigation

RIC Reconstructed Ion Chromatogram RME Reasonable Maximum Exposure

ROD Record of Decision

RPD Relative Percent Difference
RPM Remedial Project Manager
RRT Relative Retention Time
RSD Relative Standard Deviation

RSL [U.S. EPA] Regional Screening Level

RT Retention Time

SAP Sampling and Analysis Plan SDG Sample Delivery Group

SLERA Screening-Level Ecological Risk Assessment

SOP Standard Operating Procedure

SOW scope of work (or statement of work)

SQL Sample Quantitation Limit SSL Soil Screening Level SSO Site Safety Officer SSP Site Screening Process

TCLP Toxicity Characteristic Leaching Procedure

tbd to be determined TO Task Order

TOC total organic carbon

Tt Tetra Tech

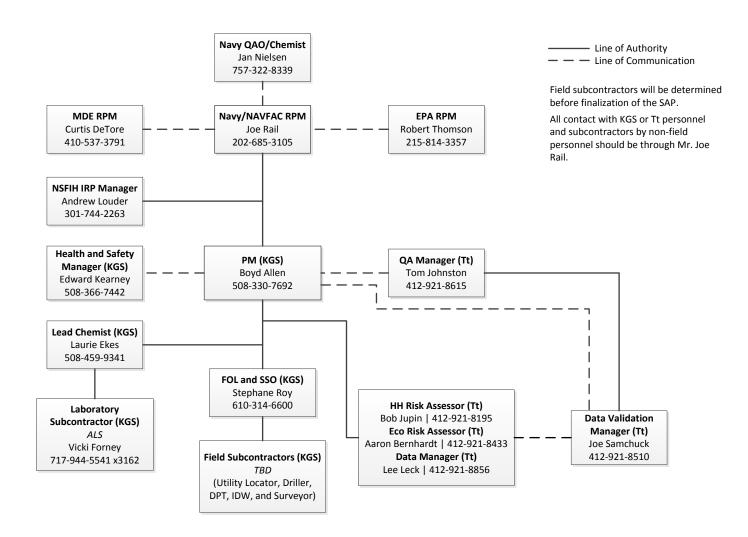
U.S. United States

UCL upper confidence limit
UFP Uniform Federal Policy
UTL upper tolerance limit

WS Worksheet

1 PROJECT ORGANIZATIONAL CHART

(UFP-QAPP Manual Section 2.4.1 and UFP-QAP Workbook WS #5)



2 COMMUNICATION PATHWAYS

(UFP-QAPP Manual Section 2.4.2 and UFP-QAPP Workbook WS #6)

Communication Drivers	Responsible Affiliation	Name	Phone Number	Procedure
Changes in schedule	PM (KGS) Navy RPM	Boyd Allen Joe Rail	508-330-7692 202-685-3105	PM informs the Navy RPM via telephone within 1 day. Navy RPM informs Regulatory RPMs via email within 7 days.
				PM will document the changes within 5 days and send the Navy RPM a concurrence letter (or equivalent) within 7 days of identifying the need for change. Navy RPM will send scope change approval to Program office before work begins.
Issues in the field that result in minor modifications of field methodology or sampling protocol	FOL (KGS) PM (KGS)	Stephane Roy Boyd Allen	610-314-6600 508-330-7692	FOL informs PM as soon as possible via phone, and PM informs Navy RPM via email within 1 day. FOL documents in field log book. Navy RPM informs Regulatory RPMs via email within 7 days.
Field conditions that result in changes in scope of field work or major modifications in field methodology or sampling protocol	FOL (KGS) PM (KGS)	Stephane Roy Boyd Allen	610-314-6600 508-330-7692	FOL informs PM as soon as possible via phone. PM informs the Navy RPM as soon as possible via phone. FOL and PM prepare a field task modification request (FTMR) within 2 days, and Navy RPM provides request to Regulatory RPMs within 2 days via email.
Recommendation to stop work and initiate work upon corrective action	FOL (KGS) PM (KGS)	Stephane Roy Boyd Allen	610-314-6600 508-330-7692	Responsible party immediately informs subcontractors, Navy, and PM via phone and email. Navy RPM informs Regulatory RPMs via email.
	QA Manager (Tt) Health & Safety Manager (KGS) Navy RPM	Tom Johnston Ed Kearney Joe Rail	412-921-8615 508-366-7442 202-685-3105	PM will inform Navy RPM (verbally or via email) by close of the next working day. Navy RPM will issue scope change approval (verbally or via email at RPM discretion). If warranted (as determined by the Navy RPM), scope change will be documented before work is executed. The FOL will document the changes on a FTMR form within 2 days of identifying the need for change and obtain required approvals within 5 days of initiating the form.
				If KGS is the responsible party for a stop work command, the FOL will inform onsite personnel, subcontractor(s), the Navy RPM, and the Facility POC (NSFIH IRP Manager) within 1 hour (verbally or by email). The Navy RPM will notify the Regulatory RPMs within 1 day. If a subcontractor is the responsible party, the subcontractor PM must inform the FOL within 15 minutes, and the FOL will then follow the procedure listed above.
Corrective Action for field program	QA Manager (Tt) PM (KGS)	Tom Johnston Boyd Allen	412-921-8615 508-330-7692	QA Manager will notify PM via email within 1 day that the corrective action has been completed. PM will then notify the Navy RPM via email within 1 day.
Field data quality issues	FOL (KGS) PM (KGS)	Stephane Roy Boyd Allen	610-314-6600 508-330-7692	FOL will inform PM via phone or by email (at FOL discretion) on the same day that a field data quality issue is discovered.

Communication Drivers	Responsible Affiliation	Name	Phone Number	Procedure
Analytical data quality issues	ALS Laboratory PM	Vicki Forney	717-944-5541 x3162	The Laboratory PM will notify (via phone or email) the Project Chemist within 1 day of when an issue related to laboratory data is discovered.
	Project Chemist (KGS) DVM (Tt)	Laurie Ekes Joe Samchuck	508-459-9341 412-921-8510	The Project Chemist will notify (via phone or via email) the data validation staff and the PM within 1 day.
	PM (KGS) Navy RPM	Boyd Allen Joe Rail	508-330-7692 202-685-3105	DVM or Project Chemist notifies PM via phone or email within 48 hours of validation completion that a non-routine and significant laboratory quality deficiency has been detected that could affect this project and/or other projects. The PM verbally advises the Navy RPM within 24 hours of notification from the Project Chemist or DVM. The Navy RPM takes corrective action that is appropriate for the identified deficiency. Examples of significant laboratory deficiencies include data reported that has a corresponding failed tune or initial calibration verification. In the event of a significant laboratory deficiency, the Navy RPM should contact the Navy Chemist/QA Officer.

Notes: KGS KOMAN Government Solutions, LLC. Tt - Tetra Tech PM - Project Manager RPM - Remedial Project Manager

QA - Quality Assurance

FOL – Field Operations Lead DV – Data Validation

FTMR – Field Task Modification Request (or Field Change Request [FCR])

DVM – Data Validation Manager

NAVFAC – Naval Facilities Engineering Command ALS – ALS Laboratories Inc.

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3 PROJECT PLANNING SESSION PARTICIPANTS SHEET

(UFP-QAPP Manual Section 2.5.1 and UFP-QAPP Workbook WS #9)

3.1 Partnering Team Scoping Session No. 1

Project Name: Site 69 Remedial Investigation (RI) Site Name: Site 69 – Building 1018 (Oxidizer Process

Building)

Projected Date(s) of Sampling:

Site Naval Support Facility Indian Head (NSFIH)

Project Manager: Boyd Allen, H&S Environmental Inc. (H&S) [now KOMAN Government Solutions, LLC (KGS)]

Date of Session: August 19, 2015

Purpose:

Scoping Session Initial scoping session for the RI at Site 69 to identify scope for the Navy-format Uniform Federal Policy (UFP)

Sampling and Analysis Plan (SAP) work plan.

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Robert Thomson	RPM	EPA Region 3	215-814-3357	thomson.bob@epa.gov	Regulatory oversight
Curtis DeTore	RPM	MDE	410-537-3791	curtis.detore@maryland.gov	Regulatory oversight
Joe Rail	RPM	NAVFAC Washington	202-685-3105	joseph.rail@navy.mil	Navy RPM
Allison Cantu	RPM	NAVFAC Washington	202-685-8056	allison.cantu@navy.mil	Navy Assistant RPM
Travis Wray	Environmental Coordinator	NSFIH	301-744-2262	travis.wray@navy.mil	Onsite/Facility IRP Manager
Ed Corack	PM	Tt	757-466-4908	ed.corack@tetratech.com	Navy Contractor
Boyd Allen	PM	H&S	508-330-7692-	ballen@hsenv.com	Navy Contractor
Margaret Kasim	Activity Manager	CH2M	703-376-5154	margaret.kasim@ch2m.com	Navy Contractor
Caitlin Bronfield	Note Taker	CH2M	703-376-5000	caitlin.bronfield@ch2m.com	Navy Contractor

This was the first scoping session for the RI at Site 69. The Team was familiar with the site based on the Site Screening Process (SSP) Investigation conducted by Tt in 2013.

The Team specified the Tier 2 UFP-SAP format should be used for this project. An addendum is appropriate, as this RI is a continuation of the work performed during the SSP for this site.

A PowerPoint presentation was displayed onscreen, and handouts were provided, with a goal of obtaining Team consensus on the scope of the RI to begin work on the SAP.

Comments/Decisions:

The SSP investigation analyzed for perchlorate and nitrate/nitrite and the results were recapitulated. Perchlorate was detected in soil, groundwater, and surface water with the highest concentrations in subsurface soil and groundwater proximate to the understood source area (former Building 1018). There were no perchlorate detections in sediment and no nitrate/nitrite issues in groundwater or surface water. Maximum surface soil concentrations are below the residential soil Regional Screening Level (RSL), but some subsurface soil concentrations closer to the source area exceed the residential soil RSL. The groundwater concentration closest to the source area exceeds the tap water RSL. There is no surface water RSL, but as a frame of reference, surface water concentrations in drainage ditches, streams, and Town Gut Creek exceed the tap water RSL (although, these waters likely would not serve as a potable source). The calculated human health risk (noncancer) exceeds a Hazard Index (HI) of 1 for subsurface soil and groundwater. Perchlorate is not a known carcinogen, so there is no cancer risk to report. The Screening-Level Ecological Risk Assessment (ERA)

(SLERA) compared SSP data to existing ecological benchmarks and concluded no unacceptable ecological risk from exposure to perchlorate in surface soil, sediment, and surface water. The uncertainty associated with a lack of accepted toxicological values for perchlorate will be revisited in the RI Report in case new studies/benchmarks become available.

Team reviewed the conceptual site model (CSM) and proposed RI objectives:

- Delineate perchlorate contamination in site soil and groundwater
- Determine extent of perchlorate source area near former Building 1018
- Determine extent of perchlorate contamination in surface water
- Complete baseline human health risk assessment (HHRA)
- Determine if further corrective action is necessary at Site 69 and/or downgradient/downstream

Team discussed the sampling approach:

- Identify extent of perchlorate in groundwater exceeding the federal Maximum Contaminant Level (MCL) and Department of Defense (DoD) Action Level of 15 micrograms per liter (µg/L) (likely to be cleanup level).
- Evaluate surface water concentrations in Town Gut Creek immediately downstream of current samples.
- Further delineate subsurface soil perchlorate to evaluate continuing source and areas to be addressed
 for direct contact risk in the Feasibility Study (FS). Note that there are no surface soil exceedances of
 the residential soil RSL (based on SSP data).

Team reviewed the proposed sample locations and offered suggestions to refine the program.

- Groundwater
 - o Collect approximately 30 direct push technology (DPT) groundwater samples in a series of lines across the site, perpendicular to groundwater flow.
 - Install up to 10 new monitoring wells based on the DPT results, and sample new and existing monitoring wells.
- Surface Water and Sediment
 - Collect 5 collocated samples of surface water and sediment: 3 samples within the ponded area adjacent to the site and 1 each on either side of the culvert beneath Atkins Spur Road (connects the two impoundments). Team dismissed the idea of extending sampling farther down Town Gut Creek past the Atkins Spur Road culvert.
- Surface and Subsurface Soil
 - Collect subsurface soil samples with corresponding surface soil samples from 12 additional borings: 6 in the immediate area surrounding the source area, 4 in the area between the source area and MW02, and 2 between MW02 and MW03.
 - Collect 6 additional surface soil samples: 2 flanking MW02, 1 in the area between MW02 and MW03, and 3 surrounding MW03.

Team discussed the proposed sampling approach of analyzing for perchlorate, only. Although the idea of full analytical suite sampling was raised, Team agreed that the review of site contaminant history and chemical

usage undertaken as part of the Uniform Federal Policy (UFP) Sampling and Analysis Plan (SAP) (UFP-SAP) approach did not suggest other contaminants of interest.

Action Items:

H&S to develop UFP-SAP (i.e., addendum to SSP SAP) and send to Team for review

Consensus Decisions:

- Limit sampling to perchlorate, only.
- There should be a collocated surface water sample with every sediment sample.
- Do not extend surface water and sediment sampling down Town Gut Creek beyond Atkins Spur Road
 at this time. However, if analytical results indicate perchlorate contamination exists in the farthest
 downstream sample collected, additional sampling may be required to delineate contamination past
 this point.
- Although no SSP surface soil sample exceeds the residential soil RSL, a surface soil sample should be collocated with all subsurface soil samples.

4 CONCEPTUAL SITE MODEL

(UFP-QAPP Manual Section 2.5.2 and UFP-QAPP Workbook WS #10)

This section summarizes the Conceptual Site Models (CSM) for Site 69 (Building 1018 – Oxidizer Process Building). See Section 5 for the Data Quality Objective (DQO) / Project Quality Objective process. Limited background information, including site location and description, site history, and a brief summary of the assumed site geology and hydrogeology are included below. Information related to pre-demolition sampling and decontamination efforts performed by Naval Support Facility (NSF) Indian Head (NSFIH) personnel and the SSP investigation (Tt, 2013 and 2015) are summarized below (also, see historical information in Appendix A).

4.1 Site Description and History

NSFIH is located approximately 25 miles southwest of Washington, D.C., in northwestern Charles County, Maryland (Figure 1), positioned along the Potomac River at the confluence of Mattawoman Creek. NSFIH has been active since 1890 and assumed its current name in 2005. As shown on Figures 1 and 2, the Main Area of the facility is bounded by the Potomac River on the northwest, west, and south, Mattawoman Creek to the south and east, and the Town of Indian Head to the northeast.

The Indian Head peninsula is located in the Atlantic Coastal Plain Physiographic Province, approximately 8 to 10 miles east of the Fall Line that marks the western extent of the physiographic province. Indian Head has gently rolling to undulating topography with elevations ranging from sea level to more than 100 feet (ft) above mean sea level (msl). The higher elevations are on the eastern portion of the facility, and the land surface generally slopes to the southwest and southeast. The portion of NSFIH along the Potomac River is characterized by 20- to 100-ft bluffs. The portion along Mattawoman Creek is more gently sloping.

Site 69 is located in the center of the Main Area (Figure 2). The estimated Installation Restoration Program (IRP) site boundary extends from former Building 1018 (initially understood source area) to Town Gut Creek (receiving water body) and measures over 9 acres (Figure 3). The site is a hilly industrial area with several buildings and structures, elevated walkways, paved roads, relatively steep earthen grass-covered bunkers, and drainage features (concrete, rip-rap with geotextile fabric, or earthen). Most of the site is covered with mowed grass, and wooded/forested areas are located along the site boundaries and within the southern portion of the site.

Topography slopes down steeply from former Building 1018 at 30 ft msl to Town Gut Creek at 5 ft msl, with some eroded drainage paths, some creeks and grassed drainage swales, and a predominant concrete drainage ditch running down the middle (Figure 4). Most of these ditches have water flowing through them year round due to groundwater discharging into them, but a few only have water during significant rain events. The ditches are only a few feet wide and typically only have a few inches of water. Some streams are present on the boundaries of the site in wooded areas. Groundwater is thought to flow through the site from north to south following site topography and discharging to Town Gut Creek. A portion of the creek bordering the south end of the site contains an emergent wetland habitat (Figure 3 and Figure 4). Town Gut Creek flows to the south through several culverts to Mattawoman Creek.

The loading dock at Building 1018 was the initial transfer location for perchlorate grains to be processed at the facility. The building was used for the grinding of ammonium perchlorate and potassium perchlorate into powder form, and the interior was washed out periodically onto the surrounding ground surface. Building 1018 and all its associated structures/features (e.g., hydraulic lift and loading dock) were demolished and removed by the Navy in 2012. CERCLA screening risk evaluations were performed as part of the SSP Investigation (Tt, 2015). Other buildings and areas at Site 69 were ruled out during the SSP based on historical site operations and

previous sampling results associated with preparation for the building demolition in 2012. Previous environmental investigations/efforts were related to compliance, pre-demolition safety and waste characterization, and spill response:

- Wastewater Sampling A wastewater sample from pooled surface water beneath the hydraulic lift off the south corner of Building 1018 was sampled by NSFIH Environmental Department in September 2006 (NSFIH, 2011). Perchlorate was detected at 110 micrograms per liter (µg/L).
- Pre-Demolition Sampling Applied Environmental performed surface soil, subsurface soil, and surface water sampling around Building 1018 in 2010. The primary objective was to characterize the type and degree of contamination in order to develop health and safety protocols for the demolition workers (Applied Environmental, 2011). Samples were analyzed for perchlorate and inorganics.

Limited geologic/hydrogeologic information was developed in the report. The subsurface soil "consisted of fine grained sand and clayey sand, silt, and mottled silty clay characteristic of natural undisturbed deposits." Groundwater was encountered at 5 ft bgs. Tadpoles and crayfish were observed in the pooled water under the hydraulic lift.

Perchlorate concentrations ranged from less than (<) 1 microgram per kilogram (μ g/kg) (nondetect) to 220 μ g/kg in surface soil and from < 1 μ g/kg (nondetect) to 14,000 μ g/kg in subsurface soil. These concentrations are below the EPA residential (55,000 μ g/kg) and industrial (820,000 μ g/kg) Regional Screening Levels (RSLs). There were no notable detections of inorganics. Perchlorate was detected at 620 μ g/L in the surface water pooled in the pit beneath the hydraulic lift. The DoD perchlorate action level, equivalent to the EPA Lifetime Health Advisory Level, is 15 μ g/L.

The report recommended developing safety precautions for demolition workers due to elevated perchlorate concentrations in soil and surface water / shallow groundwater to be encountered during demolition/removal activities. The building and associated features were demolished and removed by the Navy in 2012.

- Pre-Cleanup Sampling Following a hydraulic oil spill at the "Trident Plant" (Buildings 1034, 1035, and 1032) in fall 2011, four surface soil samples were collected and analyzed for explosives compounds (i.e., RDX, HMX, TNT, TEGDN, PGDN, NG, BTTN, TMETN, NC) prior to excavation and cleanup (NSFIH, 2011). Results showed all nondetects (< 0.1 mg/kg to < 0.3 mg/kg depending on compound).
- SSP Investigation Following the demolition of Building 1018, the Team agreed to utilize the SSP process to evaluate perchlorate contamination in the area presumably from past loading spills and subsequent washing of the building floor, loading and spill area. The investigation focused on the former building footprint and potential overland flow and drainage channels leading away from the source area down to the receiving water body (Town Gut Creek). Other buildings and areas at Site 69 were ruled out based on historical hazardous chemical usage. Tt performed surface soil, subsurface soil, groundwater, sediment, surface water sampling at the site in 2013 (Tt, 2015). The primary objective was to collect sufficient data via research, media sampling, analytical data evaluation, and risk evaluation(s) to determine whether perchlorate contamination at the site should be addressed under CERCLA (Tt, 2015). Samples were analyzed for perchlorate and nitrate/nitrite.

Perchlorate was detected in soil, groundwater, and surface water with the highest concentrations in subsurface soil and groundwater proximate to Building 1018 (source area). There were no perchlorate detections in sediment and no nitrate/nitrite issues in groundwater or surface water. The maximum surface soil concentration (2,000 μ g/kg at the source area) is below the residential soil RSL (55,000 μ g/kg) and the industrial RSL (820,000 μ g/kg). The maximum subsurface soil concentration (89,000 μ g/kg at the source area) exceeds the residential soil RSL, only. The maximum groundwater

concentration (56,000 μ g/L at the source area) exceeds the tap water RSL (14 μ g/L) and the DoD Action Level (15 μ g/L). There is no surface water RSL, but as a frame of reference, the maximum surface water concentration (23 μ g/L in the drainage ditch originating near the source area) exceeds the tap water RSL (although, surface waters in the drainage ditches, tributary creeks, and Town Gut Creek likely would not serve as potable sources).

The calculated human health risk (noncancer) exceeds a Hazard Index (HI) of 1 for subsurface soil and groundwater. A SLERA evaluated surface soil, sediment, and surface water at Site 69. Based on the initial screening of the chemical data (Tier 1, Step 2), no chemicals of potential concern (COPCs) were retained for surface water or sediment at Site 69. Several chemicals (e.g., perchlorate) were selected as COPCs in surface soil, because they were detected at concentrations that exceeded conservative screening levels or because they did not have screening levels. However, following COPC refinement in Tier 2, Step 3a, no chemicals were retained as ecological COPCs in surface soil. The uncertainty associated with a lack of accepted toxicological values for perchlorate may need to be revisited in the future as new studies may become available. The report recommended that Site 69 proceed to an RI/FS to address potential human health risk.

Based on the hydrogeology at surrounding NSFIH sites, as well as the soil boring observations from SSP Investigation, the following observations were made (Tt, 2015): The site soil matrix is predominantly clay, varying in thickness between 20 ft and 35 ft. In the north, a 15-ft-thick lens of clayey/silty fine sand overlies the clay. Interspersed through the clay are small lenses of the clayey/silty fine sand. A 10-foot (ft) thick layer of very fine to fine sand underlies the clay, thinning to an increasing thickness of organic rich clay in a north-to-south direction. A small lens of sand and gravel caps the area in the south.

The unconfined surficial aquifer occurs in this alluvial soil. The phreatic surface generally follows a slope similar to the land surface topography. Upland areas serve as groundwater recharge areas and low areas and the Creek serve as groundwater discharge areas. Groundwater flow appears to follow the surface topography at the site. Based on the sloping topography and multiple drainage features, overland flow to Town Gut Creek would be a significant migration route for spills. Figure 5 provides a three-dimensional interpretive CSM for the site. Figure 6 provides the exposure route pathway CSM for the site, which is used for the baseline human health risk assessment (HHRA).

4.2 Sources of Contamination

Ammonium and potassium perchlorate are used as an oxidizing agent for solid propellant rockets and missiles. Spilled perchlorate grains at the loading dock and historical discharges of former Building 1018 washout water directly onto the ground surface resulted in the current perchlorate contamination (Figure 5 and Appendix A). This process is resulted in the discharge of solid perchlorate and/or water containing perchlorate on the soil surface. Perchlorate present in the soils was carried vertically into the shallow water table aquifer by infiltrating rainwater. Sorption of perchlorate to the aquifer matrix is believed to be minimal, so perchlorate could be flushed from the aquifer relatively easily by ambient groundwater flow.

Perchlorate (CIO₄-) is composed of a chloride atom bonded to four oxygen atoms. Perchlorate is usually found as the anion component of a salt and is released when the solid salts of ammonium (NH₄CIO₄), sodium (NaClO₄), or potassium perchlorate (KClO₄) and perchloric acid (HClO₄) dissolve in water (Environmental Security Technology Certification Program [ESTCP], 2008; Motzer, 2001). Perchlorate salts are highly soluble in water, dissociating completely to perchlorate anions that are nonvolatile, highly mobile, and chemically stable in aqueous systems (groundwater and surface water) under normal conditions. Solid perchlorate salts and highly concentrated solutions of perchlorate [brine] can behave similarly to dense non-aqueous phase liquid (DNAPL) when released into an aquifer system. The perchlorate tends to sink through the water column until

the mass reaches a low permeability confining layer (Motzer, 2001) where it can persist and cause recurring perchlorate contamination (Interstate Technology and Regulatory Council [ITRC], 2005; ESTCP, 2008).

4.3 Contaminant Migration Mechanisms

Refer to Figure 5 and Figure 6 for primary and secondary contaminant sources, migration mechanisms, and exposure routes. Groundwater enters the unconfined shallow surficial aquifer as diffuse recharge in the upland area of the site. Discharges to the soil of solid perchlorate and/or aqueous perchlorate solutions occurred from unloading and building washout activities at former Building 1018. Perchlorate in soils were carried vertically to the surficial aquifer by infiltrating rainwater or snowmelt. Sorption of perchlorate to the aquifer matrix typically is believed to be minimal, allowing perchlorate to be flushed from the aquifer relatively easily by ambient groundwater flow (ESTCP, 2010a). This is confirmed in the surface soil at the site and in downgradient subsurface soil; however, subsurface soil perchlorate data from the 2013 SSP Investigation indicate sorbed (elevated) perchlorate at depth in the source area (89,000 μ g/kg), contributing to groundwater perchlorate contamination (56,000 μ g/L in the source area).

Perchlorate, again, is relatively soluble compared to other environmental contaminants, and generally does not adsorb strongly to sediments. This is confirmed at the site by the absence of perchlorate detections in sediment samples collected during the SSP Investigation. Sediment is being sampled again during the RI due to the nature and size of the perchlorate release(s) at the site (sediment often forgoes perchlorate analysis otherwise). Sediment and at-depth surface water samples (at sediment horizon) will be collected to complete characterization of these media and to support the risk assessment. No to low detections of perchlorate are expected in sediment and surface water. Vapor intrusion from perchlorate is not a concern. Underground utilities (potable water, sewer, telecommunications, etc.) are present at the site and may offer preferential contaminant migration pathways; however, the SSP findings suggest prolific perchlorate groundwater contamination and migration independent of utilities. The RI sampling approach will evaluate lateral distribution of perchlorate in groundwater.

4.4 Land Uses and Potential Exposure

NSFIH is a military facility with restricted access. Figure 6 presents the potential exposure routes to be evaluated in the Site 69 SSP investigation.

Current land use at Site 69 is commercial/industrial and is anticipated to remain as such for the foreseeable future. Process operations at Site 69 are conducted in multiple buildings in the area. Building 1018 was demolished in 2012. The site is located almost entirely within a K-24 explosive arc and is within multiple K-18 explosive arcs.

5 DATA QUALITY OBJECTIVES / SYSTEMATIC PLANNING PROCESS STATEMENTS

(UFP-QAPP Manual Section 2.6.1 and UFP-QAPP Workbook WS #11)

5.1 Identification of Study Goals

Based on site history and past data collection, chemical releases are known to have occurred to from perchlorate unloading and building washout operations at Site 69. Ammonium perchlorate and potassium perchlorate are the known chemicals released at Site 69. The release(s) occurred to soil directly and perchlorate contamination in the soil has migrated into groundwater and surface water, but has not impacted sediment.

The magnitude and extent of perchlorate concentrations at the site must be confirmed and established, respectively, to determine what remedial action is necessary to achieve acceptable risks for human health and the environment. The receptors representing potentially exposed organisms, and their plausible exposure pathways, are identified in Section 4. The specific goals of the RI at Site 69 are as follows:

- Delineate perchlorate contamination in site soil and groundwater
- Determine extent of perchlorate source area near former Building 1018
- Determine extent of perchlorate contamination in surface water
- Complete baseline HHRA
- Determine if further corrective action is necessary at Site 69 and/or downgradient of the site

5.2 Information/Decision Inputs

To resolve the problem stated in the Study Goals above, concentrations of the target analyte (site-related contaminant), perchlorate, must be measured in soil, sediment, surface water, and groundwater.

The SSP Investigation Report concluded perchlorate as the sole contaminant of interest. The analytical methods used to generate concentration data for this target analyte must be of sufficient sensitivity to allow detection and quantitation of the contaminant in support of project objectives. The analyses at an offsite fixed-base laboratory will be possible after sample collection in accordance with Section 7 and shipment to the laboratory.

Numerical screening criteria, or Project Screening Limits (PSLs), are needed to which measured chemical concentrations can be compared to establish the extent of contamination, to select suitable analytical methods, and to make initial estimates of human health risk for selecting chemicals of potential concern (COPCs) that are evaluated further in the HHRA. These criteria must be consistent with criteria used for other NSFIH Environmental Restoration Program (ERP)¹ investigations. There are no established NSFIH background values for perchlorate.² The criteria are presented in Section 9.

PALs are needed by which human health risks can be estimated to determine whether mitigation of risks or additional investigation is necessary. The PSLs are utilized in the first step of the HHRA to determine COPCs. The PAL for the RI is the systemic Hazard Quotient (HQ) equal to 0.1 for non-carcinogens, which, if exceeded

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¹ The Navy ERP includes both the Installation Restoration Program (IRP) and the Munitions Response Program (MRP).

² The NSFIH background data for soil and groundwater are available from the NSFIH Background Report (Tt, 2002).

in any of the environmental media, indicates potentially unacceptable level of human health risk to be evaluated further. Perchlorate is not a carcinogen, so an incremental lifetime cancer risk (ILCR) value is not needed as a PAL.

To conduct comparisons of site data to the perchlorate PSLs for surface soil, subsurface soil, sediment, surface water, and groundwater, and to complete delineation of contamination, the selected laboratory should be able to achieve low enough Limits of Quantitation (LOQs) to measure concentrations below the PSLs. Analytical data reported by the laboratory use the following reporting conventions: All results below the Detection Limit (DL) will be considered nondetects; positive results reported at concentrations between the DL and LOQ will be reported with a "J"-qualifier; and analytes not found (nondetect) in a sample will be reported at the Limit of Detection (LOD) with a "U"-qualifier.

The perchlorate PSL for groundwater and surface water (1.4 μ g/L) falls between the LOD (1.0 μ g/L) and the LOQ (2.0 μ g/L). Data that are "J"-flagged will be accepted to achieve project goals; however, greater scrutiny will be applied in these cases. The inability to quantify perchlorate to PSL levels with confidence will be addressed in the risk screening uncertainty analysis. In cases where laboratory LODs are greater than the PSLs, consistent with the *EPA Risk Assessment Guidance for Superfund, Part A* (EPA, 1989), if an analyte is not detected, the LOD is reported and "U"-qualified. An evaluation of any data impacts would be presented in the uncertainty section of the risk-ratio evaluation in the SSP Report.

For the HHRA, the exposure point concentration (EPC) for each medium will be statistically determined to summarize the data and support the risk calculations. Chemical-specific upper confidence limits (UCLs) will be calculated using EPA's latest ProUCL software. Typically, either the EPC will be the upper confidence level (UCL) of the mean chemical concentration or the EPC will be the maximum chemical concentration (depending on the number of samples and detections). Subareas can be established for evaluation at a site if warranted by the spatial distribution of the data. If the UCL is greater than the maximum detected concentration for that medium, the maximum detected concentration will represent the EPC. EPCs established in this manner represent a reasonable maximum exposure (RME). If fewer than 10 detections are observed (or fewer than 10 samples collected) for a particular target analyte in a particular environmental medium, the maximum observed concentration must be used as the EPC. Half the detection limit value will be used for a data point if the analyte is not detected.

Perchlorate Sampling. Perchlorate sample collection will be performed in accordance with Appendix F of the 2007 *DoD Perchlorate Handbook* (Appendix B). Groundwater samples will be field filtered prior to cold storage and shipment of the perchlorate samples (not required for surface water samples). Discrete soil samples will be collected instead of composite samples. Composite, multi-incremental samples will not be necessary for soil or sediment, as perchlorate is distributed relatively homogeneously due to the nature of washout activities and incidental spillage, based on the findings of the 2013 SSP. Further, no propellant matrices were observed or encountered during the SSP Investigation, and all perchlorate is understood to have immediately dissolved after previous release(s). Sediment samples will be analyzed for perchlorate because of the quantity of the historical release(s), as well as to support correlation with surface water samples also to be analyzed for perchlorate (both support the risk assessment).

Perchlorate Action Levels. DoD's perchlorate action level in groundwater is 15 μ g/L (Navy, 2010), based on EPA's Drinking Water Lifetime Health Advisory of 15 μ g/L.

Secondary Indicator Data / Aquifer Conditions Data. In addition to the target analytes, select groundwater samples will be analyzed at the laboratory for the following geochemical and aquifer condition indicators: nitrate, nitrite, chloride, sulfate, methane, and total and dissolved organic carbon (TOC and DOC, respectively). All groundwater samples will be tested for iron II with field test kits. These data will be used to evaluate the geochemistry of the aquifer including conditions that affect microbial activity (i.e., perchlorate-reducing

microbes). While nitrate is a potential co-contaminant of perchlorate and nitrite is its breakdown product, they were not detected above screening levels during the 2013 SSP Investigation. Detailed rationale for each of these indicators/parameters are provided in Section 7.4.

The following aquifer condition indicators and well stabilization parameters will be measured in the field: pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), specific conductance, temperature, and turbidity. These indicators/parameters will be measured in groundwater and surface water with a field water quality meter. For groundwater samples, the samples are not collected until these parameters stabilize. The final measurements of DO will be confirmed with field test kits considered to be more accurate than the typical field water quality meter (see Section 7.4).

Microbial Activity Indicator Data. Select groundwater samples will be analyzed by a laboratory to quantify perchlorate reducing microbes and associated enzymes (see Section 7.4). These are indicators of the potential or magnitude of active anaerobic dechlorination of perchlorate.

Physical Data. The following physical data also must be collected:

- Horizontal and vertical location data for sample locations and monitoring wells as described in Section 8.1.13.
 - Horizontal measurements (coordinates) shall be accurate to 0.1 ft.
 - Vertical elevation measurements shall be accurate to 0.01 ft.
 - Each of the locations must be surveyed in the North American Datum (NAD) of 1983, State
 Plane Coordinate System of Maryland (ft) relative to the coordinates of established site
 benchmarks or the nearest United States Geological Survey (USGS) benchmark.
- Depth to groundwater as described in Section 8.1.10 (used to compute groundwater elevations and estimate groundwater flow direction).

Quality Assurance (QA) and Quality Control (QC) Samples. Selected QA/QC samples are required to ensure data quality. New disposable polyethylene tubing must be used to purge and sample each well and to collect surface water samples. Disposable macrocore tubes and disposable trowels will be used to collect soil and sediment samples. Therefore, only one rinse/equipment blank is needed per matrix (Section 6). Duplicate samples will be collected and analyzed (see Section 6 and Section 8.3). All sample containers must be new and supplied directly from the laboratory. They must be labeled immediately upon filling, preserved appropriately (see Section 8.4), stored on ice, and submitted to the laboratory under chain-of-custody (CoC) control.

5.3 Boundaries of the Study

Two populations of each medium (soil, sediment, surface water, and groundwater) are of interest. One population is the population of material contaminated by site operations. The other is the population of uncontaminated material that helps bound the extent of contamination. Data obtained during this investigation will provide information suitable to delineating the extent of contamination at Site 69. As described in the CSM (see Section 4), the extent of contamination is not fully understood. The anticipated extent of the RI sampling and study area are shown on Figure 7. Surface soil unit measures from 0 to 1 ft bgs (human health exposure unit). Subsurface soil measures from 1 ft bgs to the water table (human health exposure unit); subsurface soil samples will target the 1-ft interval above the encountered water table. The maximum depth of interest in soil is generally the unsaturated depth to the water table in order to evaluate direct contact risk. For delineating the extent of subsurface contamination and the potential for contaminants leaching to groundwater, the maximum

extent of investigation will generally be within 15 ft bgs. Several samples may be collected deeper depending on site relief as well as to quantify the depth of contaminant migration.

The maximum depth of sediment investigation is limited to 1 ft below the sediment surface to support the evaluations of human health and to estimate the extent of contamination. While no perchlorate contamination was detected in sediments during the 2013 SSP Investigation, RI sediment sampling will focus on the southern part of the site in potential deposition areas near the pipe beneath the Atkins Spur Road (Figure 7).

For surface water in Town Gut Creek, the depth of investigation is limited to the 0 to 1 ft horizon above the sediment surface to support the HHRA and to estimate the extent of perchlorate contamination where it is most likely to be detected in surface water. Surface water samples must be collected prior to collecting sediment samples to prevent entrainment of disturbed sediment in the surface water samples. Samples will be collected from downstream to upstream.

5.4 Analytic Approach

The following decision rule must be applied to the new and existing data to resolve the problem statement:

If the extent of measured perchlorate in soil, sediment, surface water, and groundwater has been determined by the Team sufficiently well to conduct the HHRA, then conduct the risk assessment; otherwise, recommend additional data collection to support the risk assessment. There are no established applicable background levels for perchlorate, so a background comparison is not included in the approach.

5.5 Performance Criteria

Sampling locations were selected based on the needs to confirm the extent of perchlorate contamination and support the HHRA. The data to be collected under this SAP are anticipated to be sufficient to achieve these goals. Particular scrutiny will be applied to analytical results less than the LOQ when PSL/PAL is less than the LOQ. The data verification, validation, and usability evaluation processes are described in more detail in Section 12. These processes will be used to assess data quality and whether the data meet project objectives.

If any significant data gaps (i.e., quality deficiencies) are identified, the Team will document the deficiencies and determine the next appropriate step (e.g., additional data collection to fill the data gap).

5.6 Plan for Obtaining Data

The RI sampling design herein is a biased design: sampling locations were selected to supplement the previous SSP Investigation to provide results to accurately delineate the source area and full extent of perchlorate contamination. In areas with limited accessibility, the Team attempted to select sampling locations in accessible areas as close as possible to what the Team considered to be ideal location for achieving project objectives. See Section 7 and Figure 7 for the detailed sampling design.

6 FIELD QUALITY CONTROL SAMPLES

(UFP-QAPP Manual Section 2.6.2 and UFP-QAPP Workbook WS #12)

Measurement Performance Criteria (MPC) Table - Field Quality Control (QC) Samples (1)

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling, Analytical, or Both
Equipment Rinsate Blanks	Perchlorate	1 per day per matrix per sampling equipment. ⁽¹⁾	Accuracy/Bias/ Contamination	No analytes ≥ ½ Limit of Quantitation (LOQ), except common lab contaminants, which must be < LOQ.	Sampling and Analytical
Field Duplicate	Perchlorate	1 per 10 field samples collected per matrix for fixed-base laboratory analysis.	Precision	Values >5X LOQ: Relative Percent Difference (RPD) ≤30% ⁽²⁾ (aqueous); ≤50% ⁽²⁾⁽³⁾ (solid).	Sampling
Cooler Temperature Blank	All Fractions	1 per cooler.	Representativeness	Temperature must be less than 6 degrees Celsius (°C).	Sampling
MS/MSD (4)	All Fractions	1 per matrix per analytical method for each batch of at most 20 samples	Accuracy/Bias	See Section 11.0	Analytical

Notes:

- 1. Equipment rinsate blanks will be collected if non-dedicated sampling equipment is used. For disposable equipment, one sample per batch of disposable equipment will be collected for perchlorate (target analytes).
- 2. If duplicate values for non-metals are < 5x LOQ, the absolute difference should be < 2x LOQ.
- 3. If duplicate values for metals are < 5x LOQ, the absolute difference should be < 4x LOQ.
- 4. Although MS/MSDs are laboratory QC samples, they are included here because extra sample volume (typically three times) must be collected to support MS/MSD for chemical analyses.

No ambient field blanks will be collected unless warranted (no volatiles analysis, site is not dusty, no nearby emissions, etc.).

No trip blanks will be collected (no volatiles analysis, except methane, a secondary indicator in the RI).

7 SAMPLING DESIGN AND RATIONALE

(UFP-QAPP Manual Section 3.1.1 and UFP-QAPP Workbook WS #17)

7.1 Sampling Schedule

Due to explosives operations within the site (i.e., K-24 and K-18 explosive arcs), fieldwork might be restricted to weekends, only. The sampling schedule likely will vary and will be determined on a weekly basis.

7.2 Sample Selection

The RI sample locations selected by the Team are shown on Figure 7. Data from the respective media at these locations will supplement the SSP information and allow for evaluating the nature and extent of contamination, completing the baseline HHRA, and evaluating potential follow-on response action(s). Sample locations and analyses were selected to provide RI-level sample data coverage (over the current SSP-level) and to provide ample information to complete the HHRA and RI in accordance with Navy and EPA guidance(s). Detailed sample rationale is summarized in Section 7.4.

7.3 Sample Collection

Sampling for each analysis/matrix will be performed in accordance with Section 7.4 (Sample Rationale), Section 8.1 (Field Project Tasks), Section 8.3 (Sample Details), and the field Standard Operating Procedures (SOPs) provided in Appendix B (redline to be specific to this Site 69 RI effort). Notable sample boundary information is summarized in Section 5.2.

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7.4 **Sample Rationale Tables**

Matrix: Direct push technology (DPT) groundwater (48-hour Turnaround Time [TAT] to support Triad investigation approach)

Depth of Samples: tbd

Refer to Figure 7 for existing wells and other sample locations.

Analysis	Method	No. of Samples	Rationale	Sampling Strategy
Perchlorate (48-hour TAT)	SW846 6850	35 to 37 DPT locations for grab groundwater samples (35 to 37 samples, not including QA/QC)	 Target analyte / site contaminant Approximately 35 to 37 groundwater grab samples: The intent of the groundwater grab samples is to refine the delineation of the perchlorate source area and determine the lateral extent of perchlorate contamination throughout the site. Perchlorate must be delineated to less than the DoD action level of 15 μg/L. Analytical results from groundwater grab samples will be used to determine locations of permanent monitoring wells. Samples from the DPT groundwater grabs will be analyzed on a 48-hour TAT. 	 Also see Section 8. Fieldwork SOPs are provided in Appendix B. Using a Triad approach, start with collection of DPT grab groundwater samples, grouped in nine fence-line-series and perpendicular to groundwater flow (see Figure 7). Groundwater grab samples will be collected from the surficial aquifer, in the zone above the confining clay layer (approximately 16 ft bgs). The depth of the groundwater grab samples will be determined from lithology data collected during the 2013 SSP Investigation and data to be collected during this RI using DPT macrocores. Compare quick-TAT perchlorate data to DoD action level in order to select locations of up to 10 new monitoring wells (to-be-installed). Perchlorate groundwater samples will be field-filtered (0.2 micron [μm] and 0.45 μm pre-filter, if necessary, due to high turbidity) prior to containerization.

Matrix: Monitoring well groundwater

Depth of Samples: Middle of well screen

Refer to Figure 7 for existing wells and other sample locations.

Analysis	Method	No. of Samples	Monitoring Well	Rationale	Sampling Strategy
Perchlorate	SW846 6850	Up to 13 monitoring wells (13 monitoring well groundwater samples, not including QA/QC)	3 existing monitoring wells: S69MW01 through MW03. Up to 10 new, tobe-installed monitoring wells: S69MW04 through MW13.	 Target analyte / site contaminant Utilize data from the existing and additional wells to supplement previous investigation data. Collect representative samples of perchlorate from 3 existing monitoring wells and up to 10 new monitoring wells to be installed based on DPT grab groundwater data comparison to the DoD action level of 15 µg/L. Determine current perchlorate concentrations in the source area (MW01 and tbd), upgradient (tbd), and downgradient (MW02, MW03, and tbd). Determine lateral perchlorate plume configuration and boundaries utilizing new wells to be installed on either side of groundwater flow centerline (tbd), pending DPT grab groundwater perchlorate results. Confirm downgradient groundwater conditions prior to discharge into Town Gut Creek (MW03 and tbd). Provide current conditions snapshot of perchlorate throughout the surficial aquifer for HHRA calculations. Determine aquifer geochemical conditions to evaluate Fate and Transport (F&T) of perchlorate and potential remedies. 	Also see Section 8. Fieldwork SOPs are provided in Appendix B. New monitoring well locations are tbd (so they are not shown on Figure 7). Wells will be located based on spatial analysis of DPT grab groundwater perchlorate data, in order to confirm clean plume boundaries and fully characterize the site. To-be-installed wells will be 2-inch inner-diameter, Schedule 40 PVC with 0.010-inch slot 10-ft well screens. The screens will be keyed into the underlying clay unit approximately 6 inches. Perchlorate groundwater sample will be field-filtered (0.2 µm and 0.45 µm pre-filter, if necessary, due to high turbidity) prior to containerization.
Dissolved Oxygen (DO)	CHEMetrics® Test Kit	(same as above)	(same as above)	Indicator of Aquifer Conditions	(same as above)
Ferrous Iron	HACH® Field Test Kit	(same as above)	(same as above)	 Evaluate aquifer characteristics for favorable reducing conditions, per the DoD Perchlorate MNA Guidance. Preliminary MNA evaluation to be included in RI Report. DO below 0.5 mg/L suggests ideal conditions. Iron II concentrations indicate an anaerobic degradation process due to depletion of oxygen, nitrate, and manganese. Ferrous iron above 1 mg/L suggests ideal conditions. 	(same as above)

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Analysis	Method	No. of Samples	Monitoring Well	Rationale	Sampling Strategy
TOC and DOC	SW846 9060	4 monitoring wells (4 monitoring well groundwater samples, not including QA/QC)	3 existing monitoring wells: S69MW01 through MW03. 1 new, to-be- installed monitoring well: tbd	Indicators of Aquifer Conditions Evaluate aquifer characteristics for carbon/energy source to drive biodegradation via reductive dechlorination. Can be natural or anthropogenic. Establish baseline conditions for anticipated future injection remedy. Future monitoring: Compare to baseline data to evaluate electron donor (which is a carbon source) distribution, longevity, and migration.	Collect secondary indicator data to support perchlorate MNA evaluation in the RI/FS. Samples to be collected from existing and tbd monitoring wells along plume centerline within (MW01 and MW02), upgradient (tbd), and downgradient (MW03) of the source area. Dissolved TOC (DOC) groundwater samples will be field-filtered (0.45 µm) prior to containerization.
Methane	RSK175	(same as above)	(same as above)	Indicator of Aquifer Conditions	(same as above)
				 Evaluate aquifer characteristics for baseline methanogenesis. Establish baseline conditions for anticipated future injection remedy. 	
				 Future monitoring: Compare to baseline data to evaluate biodegradation steps and progress. Elevated levels of methane indicate fermentation is occurring in a highly anaerobic environment. 	
Nitrate, Nitrite,	USEPA 353.2 /	(same as above)	(same as above)	Indicators of Aquifer Conditions	(same as above)
Chloride, & Sulfate	300.0			 Nitrate and nitrite can be a direct result of the perchlorate salts release(s) if part of the salt (i.e., if the perchlorate itself was contaminated with nitrate/nitrite). Potential contaminants; however, these were not detected above screening levels during the 2013 SSP Investigation. 	
				 Evaluate aquifer characteristics for sulfanogenesis, denitrification, and electron acceptors (biodegradation steps). 	
				 At higher concentrations, sulfate may compete with the reductive dechlorination pathway. 	
				Chloride concentrations can be tracked as an indicator of perchlorate degradation (dechlorination)	
qPCR	CENSUS for	2 monitoring	2 Existing	Indicator of Degrading Microbial Behavior	Bio-Flo filter/container
	Perchlorate Reductase and Chloride	wells (2 groundwater	Monitoring Wells:	 Indicator of potential or activity of anaerobic dechlorination of perchlorate in this case. 	
	Dismutase	samples) (no QA/QC)	S69MW01 and MW03	 MW01 is in the source area and MW03 is at the downgradient end of the perchlorate plume. 	

Matrix: Surface Water

Depth of Samples: 0-1 ft horizon above sediment bottom

Refer to Figure 7 for sample locations.

Analysis	Method	No. of Samples	Rationale	Sampling Strategy
Perchlorate	SW846 6850	5 surface water sample locations (5 surface water samples, not including QA/QC)	Five surface water perchlorate samples to be collected at depth in Town Gut Creek (at locations S101 through S105), immediately downstream of 2013 SSP Investigation samples, proceeding south/downstream through discharge to first impoundment below Atkins Spur Road. Confirm downstream conditions in Town Gut Creek. Surface water near shoreline and in streams and tributaries evaluated during SSP Investigation. Provide current conditions snapshot of perchlorate and other probable site contaminants in surface water for HHRA calculations.	Also see Section 8. Fieldwork SOPs are provided in Appendix B. Surface water samples are collocated with sediment samples. In Town Gut Creek (locations S101 through S105), surface water samples to be collected at depth using a polemounted sample tubing intake—at 0-1 ft above sediment horizon where any perchlorate contamination would be most likely detected. Any detections will apply to the entire water column (human health exposure unit).

Matrix: Sediment

Depth of Samples: 0-1 ft below top of sediment

Refer to Figure 7 for sample locations.

Analysis	Method	No. of Samples	Rationale	Sampling Strategy
Perchlorate	SW846 6850	5 sediment sample locations (5 sediment samples not including QA/QC)	Five sediment samples to be collected at locations S101 through S105 (collocated with surface water samples) south of the site downstream in Town Gut Creek through discharge to first impoundment below Atkins Spur Road Sediment samples to be collected at depth in Town Gut Creek (at locations S101 through S105) immediately downstream of SSP samples. Spatial distribution along shoreline in groundwater was evaluated during SSP Investigation. Provide current conditions snapshot of perchlorate in sediment for confirming extent of contamination and for HHRA calculations.	Also see Section 8. Fieldwork SOPs are provided in Appendix B. Sediment samples are collocated with surface water samples at locations S101 through S105. All sediment samples are to be collected at 0-1 ft beneath the sediment horizon (human health exposure unit).

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Matrix: Surface Soil (Site 69) Depth of Samples: 0-1 ft bgs Refer to Figure 7 for sample locations.

Analysis	Method	No. of Samples	Rationale	Sampling Strategy
Perchlorate	SW846 6850	18 locations (18 surface soil samples not including QA/QC)	Target analyte / site contaminant Surface soil samples to be collected at six surface soil, only, locations (SO101 through SO106) and at the surface of 12 soil boring locations (SB101 through SB112). Soil samples will be collected to confirm the nature and extent of perchlorate in surface sols. Provide current conditions snapshot of perchlorate in surface soil for HHRA calculations.	Also see Section 8. Fieldwork SOPs are provided in Appendix B. Twelve of the surface soil samples are collocated with subsurface soil samples at locations SB101-SB112. The six remaining surface soil samples will be located uniformly across topography at locations SO101-SO106 to evaluate overland transport of perchlorate. Discrete sample locations (not multi-incremental). Soil to be composited from 0 to 1 ft bgs at each discrete location (human health exposure unit).

Matrix: Subsurface Soil (Site 69)

Depth of Samples: Exposure unit ranges from 1 ft bgs to water table; Anticipate sample collection above water table at approximately 7 ft bgs.

Refer to Figure 7 for sample locations.

Analysis	Method	No. of Samples	Rationale	Sampling Strategy
Perchlorate	SW846 6850	12 locations (12 subsurface soil samples not including QA/QC)	Target analytes / site contaminants Subsurface soil samples to be collected at 12 boring locations (SB101 through SB112). Subsurface soil samples will be collected to delineate perchlorate and to evaluate the continuing source area near former Building 1018, as well as downgradient areas for direct contact risk. Provide current conditions snapshot of perchlorate in subsurface soil for HHRA calculations.	Also see Section 8. Fieldwork SOPs are provided in Appendix B. All 12 subsurface soil sample locations are collocated with surface soil samples. Samples will be collected from the 1-ft interval above the water table (depth tbd) with DPT macrocores. If staining or photoionization detector (PID) responses are encountered, the impacted soil may be sampled. A strong PID response would indicate unanticipated volatiles contamination. If this occurs, the Partnering Team will have to be consulted to determine a path forward (with regard to unanticipated volatiles) Discrete sample locations (not multi-incremental). Soil to be composited from the 1-ft interval above the water table at each location. This will provide representative concentrations for use in the HHRA for the subsurface soil human health exposure unit.

8 FIELD PROJECT IMPLEMENTATION

(Field Project Instructions)

The field tasks are summarized below. A short description of each task is also provided.

- Mobilization/Demobilization
- Utility Clearance
- Field Monitoring / Equipment Calibration
- Surface Water Sampling
- Sediment Sampling
- Surface Soil Sampling
- Soil Borings and Subsurface Soil Sampling
- Water Level Measurements
- DPT Drilling and Sampling
- Monitoring Well Installation
- Monitoring Well Sampling
- IDW Management
- Surveying
- Field Equipment Decontamination Procedures
- Field Documentation Procedures
- Sample Custody and Shipment Tasks

Additional project-related tasks include:

- Analytical Tasks
- Data Management
- Project Reports

8.1 Field Project Tasks

(UFP-QAPP Manual Section 2.8.1 and UFP-QAPP Workbook WS #14)

This section provides a brief narrative for each field task, referencing the respective SOP(s) tabulated in Section 8.3 and provided in Appendix B. The SOPs are from the *Master UFP-SAP for NSFIH* (Tt, 2009) are maintained, except any deviations for this site-specific Site 69 RI effort are marked on the SOPs as red-line edits.

8.1.1 Mobilization/Demobilization

Mobilization shall consist of the delivery of all equipment, materials, and supplies to the site, the complete assembly in satisfactory working order of all such equipment at the site, and the satisfactory storage at the site of all such materials and supplies. KGS will coordinate with the facility to identify locations for the storage of equipment and supplies. Site-specific safety and health training will be provided to all subcontractors as part of the site mobilization.

The sample locations proposed and selected by the Partnering Team for the RI at Site 69 are shown on Figure 7. New monitoring well locations will be placed according to their pre-determined GPS coordinates (e.g., Maryland State Plane [ft]; see Physical Data subsection in Section 5.2) using a sub-foot accuracy GPS unit. All locations will be staked or pin-flagged during mobilization, and then reconciled with utilities (i.e., moved as necessary) during the follow-on utility clearance task.

Demobilization shall consist of the prompt and timely removal of all equipment, materials, and supplies from the site following completion of the work (including any site restoration such as seeding). Demobilization includes the cleanup and removal of IDW soil cuttings, purge water, and decontamination fluids generated during the investigation.

8.1.2 <u>Utility Clearance</u>

Prior to the commencement of any intrusive activities, the FOL will coordinate with both Miss Utility and the third-party utility subcontractor to identify and mark-out utilities that may be present within the proposed drilling areas. Following marking and reconciliation of sample locations due to any utility obstructions, a dig permit authorization will be obtained from NSFIH public works. The drilling/DPT subcontractor also will clear subsurface utilities by notifying the utility clearing service. See Facility SOP HS-1.0 for conducting subsurface soil investigations for further information.

8.1.3 Field Monitoring / Equipment Calibration / Inspection

Field equipment will be inspected and calibrated as indicated in the table below.

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	Facility SOP Reference (1)
PID	Visual Inspection, Calibration	Daily, before use	Manufacturer's Guidance	Replace	FOL or designee	SA-2.2, Manufacturer's Guidance
DPT/Drill Rig	Inspection	Daily	Equipment inspection sheet criteria	Replace	FOL or designee	GH-1.3, GH-1.5, GH-2.8, SA-2.5
Disposable Hand Trowel	Inspection	Per use	N/A	Replace	FOL or designee	SA-1.3
Water Level Meter	Visual Inspection	Daily	Manufacturer's Guidance	Replace	FOL or designee	Manufacturer's Guidance
Multi-Parameter Water Quality Meter (pH, Temperature, Specific Conductivity, DO, ORP, and turbidity)	Visual Inspection, Calibration	Daily, before use	Manufacturer's Guidance	Replace	FOL or designee	SA-1.1, Manufacturer's Guidance
Turbidity Meter	Visual Inspection, Calibration	Daily, before use	Manufacturer's Guidance; Calibrations must bracket expected values. Initial Calibration Verification (ICV) must be ±10 Nephelometric Turbidity Units (NTUs) of target value.	Replace	FOL or designee	SA-1.1, Manufacturer's Guidance
Groundwater sampling pumps and tubing	Inspect pumps, tubing and air/sample line quick-connects	Regularly	Maintained in good working order per manufacturer's recommendations	Replace	FOL or designee	SA-1.1, Manufacturer's Guidance

8.1.4 Surface Water Sampling

Surface water samples will be collected at Site 69 prior to any site disturbance to minimize any impacts from runoff. Surface water samples are to be collected prior to the collocated sediment samples in order to eliminate

potential effects of sediment particle entrainment. Samples are to be collected from downstream to upstream to similarly minimize any sediment particle entrainment. Field personnel will access the Site 69 locations in Town Gut Creek via wading or using a boat if necessary.

The five surface water samples will be collected as grab samples using a peristaltic pump with dedicated-perlocation, disposable tubing. For the samples in Town Gut Creek, the tube intake will be attached to a pole (that can reach the sediment bottom) such that the surface water sample can be collected from the 0 to 1 ft horizon above the sediment. Water quality measurements will be collected using a water quality meter with flow-through cell (same as used during groundwater sampling). Surface water sample procedures are discussed in Facility SOP SA-1.2.

8.1.5 Sediment Sampling

Field personnel will access the Site 69 locations in Town Gut Creek via wading or using a boat if necessary. The five sediment samples will be taken following collection of all five collocated surface water samples. A stainless steel Ekman or Ponar dredge (or similar device) and/or disposable trowels will be utilized to collect sediment samples from 0 to 1 ft beneath the sediment horizon in accordance with Facility SOP SA-1.2. Reusable equipment will be decontaminated between sample locations.

8.1.6 Surface Soil Sampling

Surface soil samples will be collected from 18 locations: 6 locations spread across the site and 12 locations collocated with soil boring locations as shown on Figure 7. The samples will be collected from 0 to 1 ft bgs with disposable trowels in accordance with Facility SOP SA-1.3. Discrete grab samples are appropriate for all analyses at each location during the RI. Reusable equipment will be decontaminated between sample locations.

8.1.7 Soil Borings and Subsurface Soil

Subsurface soil samples will be obtained from 12 soil boring locations using macrocores with disposable acetate liners. The proposed subsurface soil sample locations are presented on Figure 7. A truck- or track-mounted DPT and drilling rig (depending on weather/terrain conditions) will collect continuous soil cores to the target depth at each location by advancing a macrocore (4- or 5-ft) to the basal clay layer/aquitard (between 8 and 16 ft bgs depending on the site location). The core barrel assembly will be withdrawn and the soils will be screened, described, and sampled. The macrocore tool and rods (any reusable equipment) will be decontaminated between sample locations.

The soil will be described by field personnel and a boring log will be developed. Soil cores will be screened along their entire length with a photoionization detector (PID) for evidence of potential contamination. Any visual signs of potential contamination (such as soil staining) will be noted and [additional] samples will be collected.

Soil samples will be collected from the macrocores as described herein and outlined in Section 7.4. Soil sampling, soil logging, sample handling, DPT/drilling, and decontamination work procedures are discussed in Facility SOPs H-1.3, GH-1.4, GH-1.5, SAQ-1.3, SA-2.5, and SA-7.1. The use of the PID is described in the manufacturer's instructions.

8.1.8 **DPT drilling and GW sample collection**

Approximately 35 to 37 DPT groundwater samples will be collected in a series of lines across the site, perpendicular to groundwater flow. This number may be reduced based on DPT rig access and terrain. At each location, a 2-foot x 1-inch diameter mill-slotted (0.005- to 0.02-inch) well point attached to connecting rods

will be advanced to the desired depth using DPT rig. The well point will be allowed to equilibrate for at least 15 minutes, after which a measurement of the static water level will be taken. The initial measurement of the water level will be used to assess the amount of water which is present in the well point and to determine the amount of silt and sand infiltration that may have occurred.

The well point will be developed using a peristaltic pump and polyethylene tubing to remove any silt and sand that entered the well point. The well point is developed by inserting polyethylene tubing to the bottom of the well point and lifting and lowering the tubing slightly while the pump is operating. The pump will be operated at a maximum rate of approximately 2 liters per minute. After removal of sediment from the bottom of the well point, the well point will be vigorously pumped at maximum capacity until discharge water is visibly clear and no further sediments are being generated.

Measurements of pH, specific conductance, temperature, and turbidity shall be recorded every 5 to 10 minutes during the purging process. After two consistent readings of pH, specific conductance, temperature and turbidity (+/-10 percent), the well may be sampled. A sample will be collected directly from the peristaltic pump discharge using a reduced speed.

8.1.9 Monitoring Well Installation

Up to ten new monitoring wells will be installed at Site 69 (Figure 7) using the same materials and methods as other standard IRP monitoring wells. For these sites, a 10-ft screen will be installed approximately 1 ft into the basal clay layer at the bottom of the surficial aquifer (expected at approximately 15 ft bgs). Each new well will be completed with a stick-up riser, concrete pad, and protective bollards (unless flush-mount completion is requested by the facility at certain locations).

Soil borings will be drilled at the to-be-determined monitoring well locations to confirm the subsurface lithology and to ensure proper depths for well installation (to be screened just above the clay layer). The monitoring well locations will be chosen based on evaluating the spatial distribution of perchlorate in the DPT groundwater grab samples (see Section 7.4). The soil cores will be screened visually and along their entire length with a PID in accordance with the PID manufacturer's instructions. The boring information will be recorded in accordance with Facility SOP SA-6.3. The monitoring wells will be installed using hollow-stem auger (HSA) drilling methods. Monitoring well installation procedures are discussed in Facility SOP GH-2.8 and each of the new monitoring wells will be developed in accordance with this SOP.

8.1.10 Water Level Measurements

Prior to groundwater sampling, a synoptic round of groundwater level measurements will be collected from the existing three wells and the to-be-installed new wells. The depth to groundwater will be measured at each monitoring well, per Facility SOP GH-1.2. Water-level measurements will be completed within the shortest time possible on the same day, and no sooner than 24 hours after a significant precipitation event to minimize the precipitation effects on the data. Water levels at Site 69 will be collected from the wells closest to the creek first so as to minimize tidal impacts (if any) on measurements. Water level measurements will be recorded to the nearest 0.01 ft and referenced to a top of casing notch or north side of the well casing. The measurement instrument will be decontaminated prior to conducting the measurement and between each monitoring well.

8.1.11 Monitoring Well Sampling

Groundwater sampling will be conducted at each monitoring well using low-flow sampling procedures, per Facility SOP SA-1.1. A peristaltic pump with dedicated-per-well, disposable tubing will be used for groundwater sample purging and collection activities, in combination with a continuous flow-through cell suitable for taking water quality measurements. Groundwater samples will be collected and submitted for perchlorate analysis

and secondary indicator analysis (see Section 7.4). Any reusable equipment will be decontaminated between sample locations

8.1.12 IDW Management

Based on studies at other NSFIH sites and the SSP Investigation at Site 69, all IDW to be generated during the RI is assumed to be nonhazardous. However, both solid and aqueous IDW will be tested for characterization for appropriate disposal.

Waste soils will be generated during the installation of the soil borings and monitoring wells. The soil IDW will consist of the excess soil cuttings from the soil borings that were not collected for laboratory analyses, and the soils produced during the drilling of the boreholes for monitoring well installations. The waste soil will be collected and placed in 55-gallon drums for waste characterization sampling and analysis. Waste water and fluids will be generated during well installation, development, and sampling, and during all decontamination procedures for other sampling. Similar to waste soils, all aqueous IDW will be containerized in 55-gallon drums for waste characterization sampling and analysis.

All drums will be labeled and moved for storage inside the Building 1440, which has secondary containment. The driller/DPT subcontractor is responsible for safely moving and handling the drums. Pending the results of the waste characterization(s), and upon Navy approval and correct manifesting, the waste soil and water will be appropriately transported and disposed at a Navy-approved disposal facility(ies) by the IDW subcontractor.

8.1.13 Surveying

A surveyor subcontractor licensed in the state of Maryland will survey the horizontal location and vertical elevation of each of the monitoring wells (existing and to-be-installed). The horizontal measurements shall be accurate to 0.1 ft. The vertical elevation measurements shall be accurate to 0.01 ft at the top of casing / riser at each monitoring well. Each of the locations will be surveyed in the North American Datum (NAD) of 1983, State Plane Coordinate System of Maryland (ft) relative to the coordinates of established site benchmarks or the nearest United States Geological Survey (USGS) benchmark.

8.1.14 Field Equipment Decontamination Procedures

Decontamination of equipment will be conducted in accordance with Facility SOP SA-7.1. Decontamination fluids will be containerized and characterized for appropriate disposal with other IDW.

8.1.15 Field Documentation Procedures

Field documentation will be performed in accordance with Facility SOP SA-6.3. A summary of all field activities will be properly recorded in a bound logbook with consecutively numbered pages. Logbooks will be assigned to field personnel and will be stored in a secured area when not in use. At a minimum, the following information will be recorded in the site logbook and/or sample log sheets (copies to be included in subsequent RI Report):

- Name of the person to whom the logbook is assigned.
- Project name.
- Project start date.
- Names and responsibilities of on-site project personnel including subcontractor personnel.
- Arrival/departure of site visitors.
- Arrival/departure of equipment.
- Sampling activities and sample log sheet references.
- Description of subcontractor activities.

- Sample pick-up information, including chain-of-custody (CoC) numbers, air bill numbers, carrier, time, and date.
- Description of borehole or monitoring well installation activities and operations.
- Any health and safety issues.

All entries will be written in ink with no erasures. If an incorrect entry is made, striking a single line through the incorrect information will make the correction; the person making the correction will initial and date the change. Boring logs, sampling forms, and other field forms will be used to document field activities, as needed.

8.1.16 Sample Custody and Shipment Tasks

Data management and sample tracking tasks are described in Section 8.5.2 and in Facility SOP CT-05. Sample nomenclature is detailed in Section 8.3.

8.2 Field SOPs Reference Table

(UFP-QAPP Manual Section 3.1.2 - Worksheet #21)

The SOPs tabulated below for the Site 69 RI are from Appendix D of the *NSFIH Master Sampling and Analysis Plan* (Tt, 2009). Project-specific versions of the SOPs are provided in Appendix B herein: Minor deviations (or exclusions of portions) of SOPs are indicated by direct mark-up (red-line) of the SOP. This worksheet lists the SOPs to be used/referenced during the RI effort. Partial exclusions are not noted as deviations. Note that the sampling SOPs for all media for perchlorate are supplemented by the DoD (2007) perchlorate sampling SOP(s) (also provided in Appendix B).

SOP Reference Number	Title/Author and Revision Date/Number	Equipment Type	Any planned deviation for Project Work
CT-04	Sample Nomenclature, 02/04, Rev. 0	N/A	Yes
GH-1.1	Site Reconnaissance, 02/04, Rev. 0	N/A	No
GH-1.2	Evaluation of Existing Monitoring Wells and Water Level Measurement, 02/04, Rev. 0	Water level indicator	No
GH-1.3	Soil and Rock Drilling Methods, 02/04, Rev. 0	Drilling rig and accessories	No
GH-1.5	Borehole and Sample Logging, 02/04, Rev. 0	N/A	No
GH-2.8	Groundwater Monitoring Well Installation, 02/04, Rev. 0	Drilling rig, accessories, and well supplies	No
SA-1.6	Natural Attenuation Parameter Collection, 03/08, Rev. 0 Water Quality Meter and Field test kits		No
SA-1.1	Groundwater Sample Acquisition and Onsite Water Quality Testing, 03/08, Rev. 1 *Also see included DoD (2007) Perchlorate Sampling SOP.	Pump, tubing, water quality meter, and accessories	No
SA-1.2	Surface Water and Sediment Sampling, 03/08, Rev. 1 *Also see included DoD (2007) Perchlorate Sampling SOP.	Pump, tubing, pole-mount, boat, water quality meter, Ponor dredge, and accessories	No
SA-1.3	Soil Sampling, 03/08, Rev. 1 *Also see included DoD (2007) Perchlorate Sampling SOP.	Trowel, shovel, hand auger, and/or macrocore/split-barrel sampler	No
SA-2.5	Direct Push Technology (Geoprobe/Hydropunch), 02/04, Rev. 0	Drilling equipment and accessories	No

SOP Reference Number	Title/Author and Revision Date/Number	Equipment Type	Any planned deviation for Project Work
SA-2.2	Air Monitoring and Sampling, 02.04, Rev. 0	Air sampling pump and accessories, photoionization detector (PID), and/or flame ionization detector (FID)	No
SA-6.1	Non-Radiological Sample Handling, 02/04, Rev. 0	Sample bottles, packaging material, shipping materials, field filtration equipment	No
SA-6.3	Field Documentation, 02/04, Rev. 0	Field logbook, field sample forms, boring logs	No
SA-7.1	Decontamination of Field Equipment, 03/08, Rev. 1	Decontamination equipment, phosphate- free detergent, deionized water	No
HS-1.0	Utility Locating and Excavation Clearance, 02/04, Rev. 0	Remote subsurface sensing equipment, magnetometer, ground-penetrating radar	No

8.3 Sample Details Table

(UFP-QAPP Manual Sections 3.1.1 and 3.5.2.3 – Worksheets #18, 19, 20 and 30)

The table below provides the sample IDs, analyses, and QA/QC for all samples to be collected during the RI investigation at Site 69. Also, see the Analytical SOP Requirements Table in Section 8.4 for sample bottles and preservation requirements, etc.

				Depth/			Analyses
Event	Station ID	Matrix	Sample ID	Sampling Interval	Perchlorate	Perchlorate	Comments
DPT GW sampling	DPT001	groundwater	S69-DPT001	TBD	x		Three FD samples; locations to be determined in the field.
	DPT002	groundwater	S69-DPT002	TBD	Х		
	DPT003	groundwater	S69-DPT003	TBD	Х		
	DPT004	groundwater	S69-DPT004	TBD	Х		
	DPT005	groundwater	S69-DPT005	TBD	Х		
	DPT006	groundwater	S69-DPT006	TBD	Х		
	DPT007	groundwater	S69-DPT007	TBD	Х		
	DPT008	groundwater	S69-DPT008	TBD	Х		
	DPT009	groundwater	S69-DPT009	TBD	Х		
	DPT010	groundwater	S69-DPT010	TBD	Х		
	DPT011	groundwater	S69-DPT011	TBD	Х		
	DPT012	groundwater	S69-DPT012	TBD	Х		
	DPT013	groundwater	S69-DPT013	TBD	Х		
	DPT014	groundwater	S69-DPT014	TBD	Х		
	DPT015	groundwater	S69-DPT015	TBD	Х		
	DPT016	groundwater	S69-DPT016	TBD	Х		
	DPT017	groundwater	S69-DPT017	TBD	Х		
	DPT018	groundwater	S69-DPT018	TBD	Х		
	DPT019	groundwater	S69-DPT019	TBD	Х		
	DPT020	groundwater	S69-DPT020	TBD	Х		
	DPT021	groundwater	S69-DPT021	TBD	Х		
	DPT022	groundwater	S69-DPT022	TBD	Х		
	DPT023	groundwater	S69-DPT023	TBD	Х		
	DPT024	groundwater	S69-DPT024	TBD	Х		
	DPT025	groundwater	S69-DPT025	TBD	Х		
	DPT026	groundwater	S69-DPT026	TBD	Х		
	DPT027	groundwater	S69-DPT027	TBD	Х		
	DPT028	groundwater	S69-DPT028	TBD	Х		
	DPT029	groundwater	S69-DPT029	TBD	Х		

				Depth/		ı	Analyses
Event	Station ID	Matrix	Sample ID	Sampling Interval	Perchlorate	Perchlorate	Comments
	DPT030	groundwater	S69-DPT030	TBD	Х		
Monitoring Well Sampling	MW001	groundwater	S69-MW001	6-16 ft bgs		Х	Existing MW locations
	MW002	groundwater	S69-MW002	6-16 ft bgs		Χ	FD sample
	MW003	groundwater	S69-MW003	6-16 ft bgs		Χ	
	MW004	groundwater	S69-MW004	middle of screen; tbd		Х	10 new MW installed based on results from DPT sampling
	MW005	groundwater	S69-MW005	middle of screen; tbd		Χ	
	MW006	groundwater	S69-MW006	middle of screen; tbd		Χ	
	MW007	groundwater	S69-MW007	middle of screen; tbd		Χ	
	MW008	groundwater	S69-MW008	middle of screen; tbd		Χ	
	MW009	groundwater	S69-MW009	middle of screen; tbd		Χ	FD Sample
	MW010	groundwater	S69-MW010	middle of screen; tbd		Χ	
	MW011	groundwater	S69-MW011	middle of screen; tbd		Χ	
	MW012	groundwater	S69-MW012	middle of screen; tbd		Χ	
	MW013	groundwater	S69-MW013	middle of screen; tbd		Χ	
Surface Water/Sediment Sampling	S69S101	sediment	S69-SD101-001	0 - 1 foot		Х	
		surface water	S69-S101-mmddyy	at depth / just above sediment		Χ	
	0000400	sediment	S69-SD102-001	0 - 1 foot		Χ	
	S69S102	surface water	S69-SW102- mmddyy	at depth / just above sediment		Χ	
	0000400	sediment	S69-SD103-001	0 - 1 foot		Χ	FD sample
	S69S103	surface water	S69-SW103- mmddyy	at depth / just above sediment		Χ	FD sample
	0000101	sediment	S69-SD104-001	0 - 1 foot		Χ	
	S69S104	surface water	S69-SW104- mmddyy	at depth / just above sediment		Χ	
	0000405	sediment	S69-SD105-001	0 - 1 foot		Χ	
	S69S105	surface water	S69-SW105- mmddyy	at depth / just above sediment		Χ	
Surface Soil Sampling	S69SO101	surface soil	S69-SO101-001	0 - 1 foot		Χ	
	S69SO102	surface soil	S69-SO102-001	0 - 1 foot		Χ	
	S69SO103	surface soil	S69-SO103-001	0 - 1 foot		Χ	FD sample
	S69SO104	surface soil	S69-SO104-001	0 - 1 foot		Χ	
	S69SO105	surface soil	S69-SO105-001	0 - 1 foot		Χ	
	S69SO106	surface soil	S69-SO106-001	0 - 1 foot		Χ	
Surface/Subsurface Soil Sampling	S69SB101	surface soil	S69-SB101-001	0 - 1 foot		Х	
	30935101	subsurface soil	S69-SB101-xxyy	above water table		Х	
	S69SB102	surface soil	S69-SB102-001	0 - 1 foot		Χ	

				Depth/			Analyses
Event	Station ID	Matrix	Sample ID	Sampling Interval	Perchlorate	Perchlorate	Comments
	Ī	subsurface soil	S69-SB102-xxyy	above water table		Χ	
	000000400	surface soil	S69-SB103-001	0 - 1 foot		Χ	
	S69SB103	subsurface soil	S69-SB103-xxyy	above water table		Χ	
	000000404	surface soil	S69-SB104-001	0 - 1 foot		Χ	
	S69SB104	subsurface soil	S69-SB104-xxyy	above water table		Χ	
	00000105	surface soil	S69-SS105-001	0 - 1 foot		Χ	
	S69SB105	subsurface soil	S69-SB105-xxyy	above water table		Χ	
	00000400	surface soil	S69-SB106-001	0 - 1 foot		Χ	FD sample
	S69SB106	subsurface soil	S69-SB106-xxyy	above water table		Χ	FD sample
	00000407	surface soil	S69-SB107-001	0 - 1 foot		Χ	
	S69SB107	subsurface soil	S69-SB107-xxyy	above water table		Χ	
	CC0CD400	surface soil	S69-SB108-001	0 - 1 foot		Χ	
	S69SB108	subsurface soil	S69-SB108-xxyy	above water table		Χ	
	CC0CD400	surface soil	S69-SB109-001	0 - 1 foot		Χ	
	S69SB109	subsurface soil	S69-SB109-xxyy	above water table		Χ	
	000000440	surface soil	S69-SB110-001	0 - 1 foot		Χ	
	S69SB110	subsurface soil	S69-SB110-xxyy	above water table		Х	
	00000111	surface soil	S69-SB111-001	0 - 1 foot		Χ	
S69SB11		subsurface soil	S69-SB111-xxyy	above water table		Χ	
	00000440	surface soil	S69-SB112-001	0 - 1 foot		Χ	
	S69SB112	subsurface soil	S69-SB112-xxyy	above water table		Χ	

Notes: tbd – to be determined

mmddyy – two-digit month, two-digit date, two-digit year of sample collection.

xxyy – two-digit top depth and two-digit bottom depth of sample interval.

1. See field QA/QC details in Section 6. Field duplicate samples shall be designated with a "P" following the sample location number (e.g., S69-SB111*P*-0001). Equipment blank IDs shall be as follows: S69-EB01-mmddyy. MS/MSDs will retain same sample ID as parent sample ("MS/MSD" will be noted on the chain-of-custody form).

8.4 Analytical SOP Requirements Table

(UFP-QAPP Manual Section 3.1.1)

Laboratory point of contact, e-mail address, and phone number: Ms. Vicki Forney, Project Manager ALS Environmental (ALS MDT) 34 Dogwood Lane, Middletown, PA 17057 717-702-2246 (direct) or Vicki.Forney@ALSGlobal.com 717-944-5541 (main)

Data Package Turnaround Time (TAT): 21 days Tentative Sampling Dates: Winter 2015-16 (tbd)

Matrix	Analytical Group	Analytical and Preparation Method / SOP Reference (1)	Sample Size	Containers (2) (number, size, and type)	Preservation Requirements	Maximum Holding Time (3) (preparation / analysis)
Soil	Perchlorate	SW-846/6850 no grinding ALS SOP LC-MS-CLO4	30 grams (g)	One 4-ounce (oz) glass jar	Cool to 0 to 6 °C	28 days
Groundwater	Perchlorate	SW-846/6850 ALS SOP LC-MS-CLO4	100 milliliter (mL)	250 mL plastic ONLY (fill to ½-¾ full)	Cool to 0 to 6 °C	28 days
Sediment	Perchlorate	SW-846/6850 ALS SOP LC-MS-CLO4	30g	One 4-oz glass jar	Cool to 0 to 6 °C	28 days
Surface Water	Perchlorate	SW-846/6850 ALS SOP LC-MS-CLO4	100 mL	250 mL plastic ONLY (fill to ½-¾ full)	Cool to 0 to 6 °C	28 days
Groundwater	Nitrate/Nitrite	EPA 353.2/ 04-NO3	5 mL for each analyte	One 500-mL plastic bottle	Cool to 0 to 6°C	48 hours to analysis
Groundwater	Sulfide	EPA 376.1/ 04-S	250 mL	One 250 mL, zero headspace	1 mL 2-Normal zinc acetate with NaOH to pH >12; Cool to ≤ 6°C	7 days to analysis
Groundwater	Alkalinity	EPA 310.1 and SM 2320/ 04-ALK2	10 mL for each analyte	One 500-mL plastic bottle	Cool to 0 to 6°C, no preservative	14 days to analysis
Groundwater	TOC and Dissolved TOC	SW-846 9060/9060A/ 07- TOC	40 mL	Two 40-mL amber vials	HCl to pH <2; Cool to 0 to 6°C	28 days to analysis

Matrix	Analytical Group	Analytical and Preparation Method / SOP Reference (1)	Sample Size	Containers (2) (number, size, and type)	Preservation Requirements	Maximum Holding Time (3) (preparation / analysis)
Solid IDW ⁴	TCLP – Full Suite	SW-846 1311, 6010C, 7470A, 8270D	100 g	One 8-oz wide-mouth glass jar	Cool to 0 to 6 °C	28 days from sampled date to leaching, 28 days from leaching to analysis
Solid IDW ⁴	Ignitability	SW-846 1010	20 g	One 4-oz wide-mouth glass jar	Cool to 0 to 6 °C	As soon as possible after laboratory receipt
Aqueous IDW ⁴	TCLP – Full Suite	SW-846 1311, 6010C, 7470A, 8270D	500 mL	One 1-L HDPE bottle	Cool to 0 to 6 °C	28 days from sampled date to leaching, 28 days from leaching to analysis
Aqueous IDW 4	Corrosivity (pH)	SW-846 9045C	500mL	One 1-L HDPE bottle	Cool to 0 to 6 °C	As soon as possible after laboratory receipt
Aqueous IDW 4	Ignitability	SW-846 1010	100 mL	One 100-mL HDPE bottle	Cool to 0 to 6 °C	As soon as possible after laboratory receipt
Groundwater - Microbial ⁽⁵⁾	Perchlorate reductase gene (pcrA)	Laboratory proprietary Methods, MI SOP DNA- qPCR, MI SOP DNA Ext	1L	Bio-Flo Filters (containers)	Cool to 0 to 6 °C	Extract within 28 hours and freeze at -20°C until analysis
Groundwater - Microbial ⁽⁵⁾	Chlorite dismutase gene (cld)	Laboratory proprietary Methods, MI SOP DNA- qPCR, MI SOP DNA Ext	1L	Bio-Flo Filters (containers)	Cool to 0 to 6 °C	Extract within 28 hours and freeze at -20°C until analysis

Notes: ALS Laboratory mL – milliliter g – gram L – liter oz – ounce °C – Degrees Celsius TCLP – Toxicity Characteristic Leaching Procedure

- 1. Laboratory SOPs are subject to revision and updates during duration of the project, the laboratory will use the most current revision of the SOP at the time of analysis.
- 2. Sample size is a minimum; the containers listed will be filled to compensate for any required re-analysis or re-extractions. For samples requiring Matrix Spike (MS)/Matrix Spike Duplicate (MSD), containers listed should be tripled.
- 3. Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted.
- 4. IDW sample analyses are presented on this worksheet for the utilization of field personnel. Quality control information is not presented in any of the remaining WSs for these samples.
- 5. Microbial sample analyses are presented in this section for the utilization of field personnel. Quality control information is not presented in any of the remaining WSs for these samples

8.5 Additional Project-Related Tasks

Additional project-related tasks include the following:

- Analytical tasks
- Data management
- Assessment and oversight
- Data review
- Project reports

8.5.1 Analytical Tasks

Chemical analyses will be performed by ALS Environmental. ALS is Department of Defense (DoD) Environmental Laboratory Program (ELAP)-accredited. A copy of the laboratory accreditation is located in Appendix C. Analyses will be performed in accordance with the analytical methods specified in Section 8.2. ALS will meet most of the PSLs/PALs as shown in Section 9. ALS will perform chemical analysis following laboratory-specific SOPs (Section 10).

All soil results will be reported by the laboratory on a dry-weight basis. Results of percent moisture will be reported in each analytical data package and electronic data deliverable (EDD). This information also will be captured in the project database, which will eventually be uploaded to Naval Installation Restoration Information Solution (NIRIS).

The analytical data packages provided by ALS will be in a Contract Laboratory Program (CLP)-like format; containing raw data capable of full data validation, to include summary forms for all sample and laboratory method blank data, and all method-specific QC information (results, recoveries, relative percent differences [RPDs], relative standard deviation [RSDs], and/or percent differences [%Ds], etc.).

8.5.2 <u>Data Management</u>

The principal data generated for this project will be from field and laboratory analytical data. Field sampling log sheets will be organized by date and medium, and filed in the project files. The field logbooks for this project will be used only for this site and will also be categorized and maintained in the project files after the completion of the field program. Project personnel completing concurrent field sampling activities may maintain multiple field logbooks.

The laboratory data handling procedures will meet the requirements of the technical specifications. The project chemist (or designee) is responsible for the overall tracking and control of data generated for the project.

Data Tracking. Data are tracked from generation to archiving. The Project Chemist (or designee) is responsible for tracking the samples collected and shipped to ALS. Upon receipt of the data packages from ALS, the Project Chemist will monitor the data validation effort, which includes verifying that the data packages are complete and all sample results have been reported.

Data Storage, Archiving, and Retrieval. Data packages and field records; including field log books, sample logs, chain-of-custody records, and field calibration logs, will be submitted by the FOL to be entered into the Navy CLEAN file system prior to archiving in secure project files.

Data Security. Access to project files is restricted to designated personnel only. The Data Manager maintains the electronic data files. File and data backup procedures are routinely performed.

Electronic Data. All electronic data will be compiled into a NIRIS Electronic Data Deliverable (NEDD) and loaded into NIRIS.

Data Review. This review comprises data verification, validation, and usability assessment. The data verification and validation processes and requirements are described in Section 12. The data usability assessment will, at a minimum, constitute evaluation of the following characteristics to ensure that the amount, type, and quality of data are sufficient to achieve project objectives. The means of conducting these evaluations will vary depending on the nature of the data. For example, soil borings and well construction logs will generally be evaluated qualitatively or semi-quantitatively whereas precision, accuracy, and sensitivity of analytical data will generally be evaluated quantitatively and may be based on, or may supplement, data validation findings. Examples include the following:

- Comparing actual to intended sampling locations and verifying that the correct datum was used to delineate contamination.
- Identifying potential errant or outlier data points.
- · Assessing planning assumption validity.
- Evaluating the potential for contamination of samples by samplers.

Data quality indicators to be evaluated during this assessment include the following:

- 1. **Precision.** A semi-quantitative estimate of the uncertainty in contaminant concentrations as a function of location will be made.
- 2. **Accuracy.** Accuracy data will be evaluated to ensure sampling and measurement accuracy is within or exceeds analytical method specifications and may depend in part on the data validation findings.
- Representativeness. This evaluation will assess whether the data are adequately representative of intended populations based on the sample collection and data generation requirements specified in this SAP.
- 4. Completeness. Failure to obtain critical data from planned locations will be documented. Minor variations in actual versus intended sampling locations (or depths) that do not adversely affect the attainment of project objectives will not be documented.
- 5. **Comparability.** This will be accomplished by verifying that the planned analysis was used and that the data quality indicators reviewed during data validation indicate no significant data quality deficiencies.
- 6. **Sensitivity.** The Tt Project Chemist will determine whether project sensitivity goals were achieved by comparing non-detect values to PSLs/PALs.
- 7. Other quantitative characteristics. These may include quantities such as verification of soil volume calculations, soil disposal cost estimates, etc., that are used to determine whether the contaminants are sufficiently well delineated to estimate remediation costs.

If significant data quality deficiencies are detected that prevent the attainment of project objectives, the limitations on the affected data will be described in the project report. The Tt PM will bring these deficiencies to the attention of the project team for their evaluation and the team will determine an appropriate corrective action depending on the circumstances.

8.5.3 Project Reports

A Draft RI Report will be prepared and submitted to the Navy and regulators (i.e., the Partnering Team) for review. The report will include a summary of the work performed in the approved UFP-SAP, field modifications as documented by the FOL, summary and analysis of the analytical results, updated CSM, human health and ecological risk screening evaluations, and conclusions and/or recommendations for the sites. KGS will respond to comments received on the draft report. The final version of the report will be submitted in hardcopy and electronic format to the project stakeholders.

The report will contain a *results and data quality* section (or equivalent contained within data validation memoranda), which will present the analytical data and identify site-related contamination, and include an evaluation of the data as they relate to the nature and extent of contamination and both human health and ecological risk screening evaluations. It also will include a summary of quantitative analytical performance indicators such as completeness, precision, bias, and sensitivity and qualitative indicators such as representativeness and comparability. There will be a reconciliation of project data with the DQOs and an identification of deviations from this UFP-SAP. A data usability assessment will be used to identify significant deviations in analytical performance that could affect the ability to meet project objectives.

The Partnering Team will be updated throughout the RI investigation fieldwork via email, conference call, and/or Partnering meetings. At least one summary presentation will provided at a Partnering meeting prior to or just after submission of the draft report.

9 REFERENCE LIMITS AND EVALUATION TABLES

(UFP-QAPP Manual Section 2.8.1 and UFP-QAPP Workbook WS #15)

Matrix: Soil/Sediment

Chemical / Analyte		PSL/PAL PSL/PAL		DOL C	ALS		
	CAS Number	PSL/PAL (mg/kg)	Reference (1)	PQLG (mg/kg) ⁽²⁾	LOQ (mg/kg)	LOD (mg/kg)	DL (mg/kg)
PERCHLORATE - 6850	14797-73-0	5.5	EPA RSL	1.83	0.020	0.010	0.010

Notes:

There are no Project Screening Limits (PSL) and/or Project Action Limit (PAL) values between the laboratory Limit of Quantitation (LOQ) and the Limit of Detection (LOD).

- 1. Selected PSL/PAL is the lowest (most conservative) of the evaluated PSLs/PALs.
- 2. Project Quantitation Limit Goal (PQLG) is set at 1/3 the PSL/PAL.

CAS - Chemical Abstract Service mg/kg - milligrams per kilogram LOQ - Limit of Quantitation LOD - Limit of Detection DL - Detection Limit

EPA RSL – EPA (November 2015) residential soil RSL. RSLs based on non-carcinogenic effects (as is the case for perchlorate) have been divided by 10 to account for exposure to multiple constituents (as a formality in this case, because there is only one constituent, perchlorate).

Matrix: Surface Water/Groundwater

		DOL/DAI	DOL /DAI	POL 0		ALS	
Chemical / Analyte	CAS Number	PSL/PAL (µg/L)	PSL/PAL Reference (1)(3)	PQLG (µg/L) ⁽²⁾	LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
TARGET ANALYTE							
PERCHLORATE - 6850	14797-73-0	1.4	EPA RSL	0.4	2.0	1.0	1.0
MISCELLANEOUS							
CHLORIDE – EPA 300.0	N/A	250,000	Other	83,333	1.0 mg/L	0.2 mg/L	0.08 mg/L
NITRATE – EPA 300.0	14797-55-8	500	Other	167	0.5 mg/L	0.18 mg/L	0.01 mg/L
NITRITE – EPA 300.0	14797-65-0	500	Other	167	0.3 mg/L	0.13 mg/L	0.03 mg/L
SULFATE – EPA 300.0	14808-79-8	250,000	Other	83,333	0.5 mg/L	0.35 mg/L	0.13 mg/L
TOTAL ORGANIC CARBON (TOC) – 9060	NA	10,000	Other	3,333	1.0 mg/L	0.2 mg/L	0.08 mg/L
DISSOLVED ORGANIC CARBON (DOC) – 9060V	NA	NA	NA	3,333	1.0 mg/L	0.2 mg/L	0.08 mg/L
Methane – RSK 175	74-82-8	10	Other	3.33	1.0	0.45	0.25

9. REFERENCE LIMITS AND EVALUATION TABLES

Notes

Bold rows indicate that the Project Screening Limit (PSL) and/or Project Action Limit (PAL) is between the laboratory Limit of Quantitation (LOQ) and the Limit of Detection (LOD).

CAS – Chemical Abstract Service µg/L – micrograms per Liter LOQ – Limit of Quantitation LOD – Limit of Detection DL – Detection Limit

- 1. Selected PSL/PAL is the lowest (most conservative) of the evaluated PSLs/PALs.
- 2. Project Quantitation Limit Goal (PQLG) is set at 1/3 the PSL/PAL.
- 3. PAL References (may be updated appropriately at time of data evaluation / RI Report preparation):
 - EPA RSL U.S. EPA (November 2015) tap water RSL. RSLs based on non-carcinogenic effects (as is the case for perchlorate) have been divided by 10 to account for exposure to multiple constituents (as a formality in this case, because there is only one constituent, perchlorate).
 - Other Less than the Federal Maximum Contaminant Level (MCL) for nitrate (10,000 μg/L as nitrogen) and nitrite (1,000 μg/L as nitrogen), and less than the Secondary MCLs for chloride and sulfate (250,000 μg/L). EPA (April 2012) Drinking Water Standards & Health Advisories. EPA 822-S-12-001. Office of Water. Washington, D.C. PSLs for TOC/DOC and methane based on professional judgment.

10 ANALYTICAL SOP REFERENCES

(UFP-QAPP Manual Section 3.2.1 and UFP-QAPP Workbook WS #23)

Main Laboratory point of contact, e-mail address, and phone number:

Ms. Vicki Forney, Project Manager **ALS Environmental** 34 Dogwood Lane, Middletown, PA 17057 717-702-2246 (direct) or Vicki.Forney@ALSGlobal.com 717-944-5541 (main)

ALS Environmental (ALS MDT) 34 Dogwood Lane Middletown, PA 17057

ALS Environmental (ALS SL) 960 West LeVoy Drive Salt Lake City, UT 84123

Microbial Analysis Laboratory:

Casey Brown, cbrown@microbe.com, 865.573.8188 ext 103 Microbial Insights, Inc. | 10515 Research Drive | Knoxville, TN 37932

Data Package Turnaround Time: 21 days **Tentative Sampling Dates:** Spring 2015 (TBD)

Data Package Turnaround Time: 21 days **Tentative Sampling Dates: Winter 2016** (tbd)

Lab SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Variance to QSM? Y/N	Modified for Project Work? ⁽¹⁾
LC/MS- CLO4	The Determination of Perchlorate in Water, Soil and Biota by Liquid Chromatography / Mass Spectrometry, 9/15/14 Rev 9	Definitive	Soil, Surface Water, Sediment, Groundwater, and Aqueous QC samples / Perchlorates	Liquid Chromatography / Mass Spectrometry	ALS SL	N	N
HPL9056	Inorganic Anion Analysis; Rev. 7; 03/2015	Definitive	Groundwater: Anions (nitrate, nitrite, chloride, and sulfate)	Ion Chromatography (IC)	ALS MDT	N	N
ANA353.2	Total Oxidizable Nitrogen, Nitrate, and Nitrite Analysis, EPA Method 353.2; Rev. 3; 06/2014	Definitive	Groundwater: Nitrate/Nitrite	IC	ALS MDT	N	N

10. ANALYTICAL SOP REFERENCES

Lab SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Variance to QSM? Y/N	Modified for Project Work? ⁽¹⁾
ANA9060A	Total Organic Carbon in Water (Non-purgeable Organic Carbon) SW846 Method 9060A; Rev. 11; 06/2014	Definitive	Groundwater: TOC and DOC		ALS SL	NA	N
ANARSK- 175	Dissolved gas analysis in water by headspace gas chromatography; Rev. 4; 01/2015	Definitive	Groundwater: Dissolved Methane	Gas Chromatography (GC)	ALS MDT	NA	N
MI SOP-DNA EXT	Extraction of DNA from Environmental Samples (matrix-water, soil, biofilm, bio- Sep beads) (Revision 1.2, 01/10/06)	Screening	Groundwater/DNA Extraction	Incubator	Microbial Insights	NA	N
MI SOP-DNA qPCR	Quantitative Polymerase Chain Reaction (qPCR) (Revision 1.2, 01/10/06)	Screening	Groundwater/ qPCR	Applied Biosystems	Microbial Insights	NA	N

Notes:

Lab Accreditation or Certification requirements for the work of this project have been verified. Copies are provided in Appendix C.

11 LABORATORY QC SAMPLES TABLE

(UFP-QAPP Manual Section 3.4 and UFP-QAPP Workbook WS #28)

Matrix: Soil, Sediment, Surface Water, Groundwater, and Aqueous QC Blanks

Analytical Group: Perchlorate

Analytical Method/SOP Reference: SW-846 6850 / ALS SOP- LC-MS-CLO4

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	DQI	MPC
Isotope Ratio ³⁵ Cl/ ³⁷ Cl	Every sample, batch QC sample, and standard.	Monitor for the daughter ion at masses 83/85. Theoretical ratio ~3.06. Ratio must be within 2.3 to 3.8.	If criteria are not met, a positive is not reported. If, after cleanup, the ratio still fails, use alternative techniques to confirm presence of perchlorate.	Analyst, Supervisor	Accuracy/ Bias	Same as Method/SOP QC Acceptance Limits.
IS	Every sample, batch QC sample, standard, instrument blank, and method blank.	Measured ¹⁸ O IS area must be within 50% to 150% of the average IS area counts of the ICAL. RRT of the perchlorate ion must be within 0.98 to 1.02.	Rerun the sample at increasing dilutions until the 50-150% acceptance criteria is met. If criteria cannot be met with dilution, interference is suspected - use additional pretreatment steps.	Analyst, Supervisor	Accuracy/ Bias	Same as Method/SOP QC Acceptance Limits.
Interference Check Sample (ICS)	One per batch to verify method performance at the matrix conductivity threshold (MCT). At least one ICS must be analyzed daily.	The %R must be within 70% to 130% of true value.	Correct problem and re-analyze all samples in that batch. Replace cleanup filters or column if necessary. No samples may be reported that are associated with a failing ICS.	Analyst, Supervisor	Accuracy/ Bias	Same as Method/SOP QC Acceptance Limits.
Method Blank	One per preparatory batch of 20 or fewer samples.	Perchlorate must be ≤ ½ LOQ.	Investigate source of contamination and evaluate the samples and associated QC: i.e., if the blank results are above ½ LOQ, then report sample results that are non-detect. Otherwise, re-prepare blank and associated samples.	Analyst, Supervisor	Bias/ Contamination	Same as Method/SOP QC Acceptance Limits.
LCS (LCSD not required)	One per preparatory batch of 20 or fewer samples.	%Rs must be between 80% and 120%. RPD should be ≤15%, if LCSD is analyzed.	If the %R of a target analyte in the LCS is greater than the upper control limit, and there are no positive findings for that compound, no further action is taken. Otherwise, re-analyze the LCS and affected samples or flag the results. If the %R of any target analyte is below the lower control limit, re-analyze the LCS and affected samples.	Analyst, Supervisor	Accuracy/ Bias Precision also, if LCSD is analyzed	Same as Method/SOP QC Acceptance Limits.

11. LABORATORY QC SAMPLES TABLE

QC Sample	Frequency / Number	Frequency / Number Method / SOP QC Acceptance Limits Corrective Action		Person(s) Responsible for CA	DQI	MPC
MS/MSD	One per preparatory batch of 20 or fewer samples per matrix. The MS and MSD must be spiked at the LOQ.	%Rs should be between 80% and 120%. RPD should be ≤15%	Flag the parent sample for failed analytes, which exceed the acceptance criteria.	Analyst, Supervisor	Accuracy/ Bias/ Precision	Same as Method/SOP QC Acceptance Limits.

Matrix: Groundwater, and Aqueous QC Blanks Analytical Group: Nitrate/Nitrite Analytical Method/SOP Reference: EPA 353.2 / ANA353.2

QC Sample	Frequency / Number Method / SOP QC Acceptance Limits Corrective Action		Person(s) Responsible for CA	DQI	MPC	
Method Blank	One per batch of up to 20 samples	Analyte concentration must be <1/2 LOQ.	Correct problem, re-prepare and reanalyze along with associated samples.	Analyst, Supervisor	Contamination / Bias	Same as QC Acceptance Limits.
LCS	One per batch of up to 20 samples	%R must be within 90- 110%.	Correct problem, re-prepare, and reanalyze along with associated samples.	Analyst, Supervisor	Accuracy / Bias	Same as QC Acceptance Limits.
MS/MSD	One set is performed for each batch of up to 10 samples of the same matrix. %R must be between 80-120%, MS/MSD %RPD must be <20%.		Failure to meet the control limits will be discussed in the case narrative. If both the LCS and MS are unacceptable, all associated samples must be re-analyzed.	Analyst, Supervisor	Precision / Accuracy	Same as Method/SOP QC Acceptance Limits.

Matrix: Groundwater, and Aqueous QC Blanks Analytical Group: Anions Analytical Method/SOP Reference: EPA 300.0 / ANA300.0

QC Sample	Frequency / Number	y / Number		Person(s) Responsible for CA	DQI	MPC
Method Blank	One per batch of up to 20 samples	Analyte concentration must be <½ LOQ.	Correct problem, re-prepare and reanalyze along with associated samples.	Analyst, Supervisor	Contamination /Bias	Same as QC Acceptance Limits.
LCS	One per batch of up to 20 samples	%R must be within 90- 110%.	Correct problem, re-prepare, and reanalyze along with associated samples.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits.
MS/MSD	for each batch of up to 10 samples of the same matrix. 120%, MS/MSD %RPD must be <20%.		Failure to meet the control limits shall be discussed in the case narrative. If both the LCS and MS are unacceptable, all associated samples must be reanalyzed.	Analyst, Supervisor	Precision / Accuracy	Same as Method/SOP QC Acceptance Limits.

Matrix: Soil, Groundwater, and Aqueous QC Blanks Analytical Group: TOC/DOC Analytical Method/SOP Reference: SW846 Method 9060 / ANA9060A

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch of 20 or fewer samples	The target analyte must be ≤ ½ LOQ.	Correct problem, re-prepare and reanalyze along with associated samples.	Analyst, Supervisor	Bias/ Contamination	Same as QC Acceptance Limits
LCS	One per preparatory batch of 20 or fewer samples	%R must be within 80- 120% of true value.	Correct problem, re-prepare, and reanalyze along with associated samples.	Analyst, Supervisor	Accuracy/ Bias	Same as QC Acceptance Limits
MS/MSD	One per preparatory batch of 20 or fewer samples per matrix RPD should be		Contact client for guidance.	Analyst, Supervisor	Accuracy/ Bias/ Precision	Same as QC Acceptance Limits

Matrix: Groundwater, and Aqueous QC Blanks Analytical Group: Dissolved Methane Analytical Method/SOP Reference: RSK SOP 175 / ANARSK-175

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action		DQI	MPC
Method Blank	One per batch of up to 20 samples	Analyte concentration must be < ½ LOQ.	Correct problem, re-prepare and reanalyze along with associated samples.	Analyst, Supervisor	Contamination /Bias	Same as QC Acceptance Limits.
LCS	One per batch of up to 20 samples	%R must be within70- 130% of the expected value.	Correct problem, re-prepare, and reanalyze along with associated samples.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits.
MS/MSD	One per batch of up to 20 samples	%R should be within 70- 130% of the expected value. RPD ≤ 30%	Contact client for guidance.	Analyst, Supervisor	Accuracy/Bias/P recision	Same as QC Acceptance Limits.

Project-Specific Tier 2 UFP-SAP Revision: 2 Date: August 2016

12 DATA VERIFCATION AND VALIDATION (STEPS I AND IIa/IIb) PROCESS TABLE

(UFP-QAPP Manual Section 5.2.1, Section 5.2.2, Table 9, and Figure 37; and UFP-QAPP Workbook WS #34, #35, and #36)

Data Review Input	Description	Responsible for Verification	Internal/ External
Chain of Custody (CoC) Forms	The KGS FOL or designee will review and sign the CoC to verify that all samples listed are included in the shipment to the laboratory and the sample information is accurate. The CoC will be signed by the sampler and a copy will be retained for the project file. The original CoC will be taped inside the cooler in a waterproof bag for shipment with the samples to the laboratory. Any field deviations should be documented in the field log book.	Sampler and FOL	Internal
CoCs and SAP	Verify that the correct sampling and analytical methods/SOPs were applied and requested on the CoC. Verify that the sampling plan was implemented and carried out as written and that any deviations are documented. Document any discrepancies in the final report.	Sampler and FOL	Internal
CoCs	The Laboratory Sample Custodian will review the sample shipment for completeness and integrity, and sign accepting the shipment. Any discrepancies will be communicated by the laboratory PM to the FOL or designee.	Laboratory Sample Custodian	External
Analytical SOPs, and Analytical Data Packages	Ensure that all laboratory SOPs were followed. Verify that the correct analytical methods/SOPs were applied. Establish that holding times were met and that all method QC samples were analyzed and in control as listed in the analytical SOPs. If holding times were not met, the laboratory PM will contact the contractor or designee for approval to proceed. All QC deviations or non-compliances shall be noted in the case narrative.	Laboratory QAM or PM	External
Analytical Data Package Deliverable	Verify all analytical data packages for completeness. The Laboratory QAM or designee will review and sign the case narrative for each data package.	Laboratory QAM or PM	External
SAP/ Laboratory Data Packages/ EDDs	Verify each data package for completeness. Request missing information from the Laboratory PM. Check that the CoC was signed and dated by the FOL or designee relinquishing the samples and also by the Laboratory Sample Custodian receiving the samples for analyses. Document any deviations. Review that the samples were shipped and stored at the required temperature and preservation conditions for chemically-preserved samples meet the requirements listed in the SAP. Ensure that the analyses were performed within the holding times listed in the Laboratory SOPs and SAP.	Data Validators, KGS	Internal
SAP/ Laboratory Data Packages/ EDDs	Ensure that the laboratory QC samples were analyzed and that the MPCs listed in were met for all field samples and QC analyses. Check that specified field QC samples were collected and analyzed and that the analytical QC criteria set up for this project were met.	Data Validators, KGS	Internal
SAP/ Laboratory Data Packages/ EDDs	Check the field sampling precision by calculating RPDs for field duplicate samples. Check laboratory precision by reviewing the RPD or percent difference values from laboratory duplicate analyses; MS/MSDs; and LCS/LCSD, if available. Ensure compliance with the methods and project MPCs accuracy goals listed in the SAP.	Data Validators, KGS	Internal
SAP/ Laboratory Data Packages/ EDDs	Check each EDD against the hard copy data package for accuracy and completeness. Compare laboratory analytical results to the electronic analytical results to verify accuracy. Evaluate sample results for laboratory contamination and qualify false detections using the laboratory method/preparation blank summaries. Qualify analyte concentrations between the DL and the LOQ as estimated.	Data Validators, KGS	Internal
SAP/ Laboratory Data Packages/ EDDs	Ensure that the project LOQs listed in SAP were achieved.	Data Validators, KGS	Internal
SAP/ Laboratory Data Packages/ EDDs	Discuss the impact on elevated Detection Limits due to matrix interferences. Evaluate the impact of sample dilutions on low-concentration analytes when the dilution was performed because of the high concentration of one or more other contaminants. Document this usability issue and inform the KGS PM. Review data against PSLs/PALs.	Data Validators, KGS	Internal

Data Review Input	Description	Responsible for Verification	Internal/ External
SAP/ Laboratory Data Packages/ EDDs	Determine the impact of any deviation from analytical methods and SOP requirements and matrix interferences effect on the analytical results. Qualify data results based on method or QC deviation and explain all the data qualifications. Determine if the data met the MPCs and determine the impact of any deviations on the technical usability of the data. Summarize data review including any deviations in the Data Validation Report. Data Validation reports will be created for every laboratory data package.	Data Validators, KGS	Internal

12.1 Validation Summary

Analytical Group	Validation Criteria	Data Validator (title and organizational affiliation)
Perchlorate	Full validation will be performed using criteria for SW-846 Method 6850 listed in this SAP and the current DoD QSM. The logic outlined in the Region 3 Modifications to the National Functional Guidelines for Organic Data Review (EPA, 1994) should be used to apply qualifiers to data.	Data Validation Specialist, KGS
TOC, Anions, Dissolved Methane, Nitrate/Nitrite	Validation will be performed using the method specific criteria listed in this SAP and the current DOD QSM to the extent possible will be used.	Data Validation Specialist, KGS

Full data validation is defined as in-depth examination of data to check for adherence to method requirements, technical quality, analyte identification, and result quantitation. It is conducted to support risk assessments and to propose No Further Action scenarios. A formal report (or memorandum) is prepared which details technical findings, presents qualified analytical data and results as reported by the laboratory prior to validation, and includes laboratory quality control summaries and calculation verifications as supporting documentation. IDW analyses will not be validated.

REFERENCES

Applied Environmental, 2011. Soil/Water Sampling Report, Building 1018, Naval Support Facility Indian Head, Maryland. Prepared for Eastern Research Group. January 20.

DoD (Department of Defense), 2007. *DoD Perchlorate Handbook*. Revision 1, Change 1. Department of Defense Environmental Data Quality Workgroup. August.

DoD, 2013. Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0. July.

ESTCP (Environmental Security Technology Certification Program), 2008. *Natural Attenuation of Perchlorate in Groundwater: Processes, Tools, and Monitoring Techniques*. ESTCP Project No. ER-0428. Prepared by Solutions-IES, Inc. August.

ITRC (Interstate Technology and Regulatory Council), 2005. *Perchlorate: Overview of Issues, Status, and Remedial Options*. September. http://www.itrcweb.org.

Motzer, W.E., 2001. Perchlorate Problems, Detection, and Solutions. Environmental Forensics 2(4): 301-311.

ITRC (Interstate Technology and Regulatory Council), 2005. *Perchlorate: Overview of Issues, Status, and Remedial Options*. September. http://www.itrcweb.org.

Navy/USEPA, 2000. Federal Facilities Agreement Under CERCLA Section 120, Administrative Docket Number: III-FCA-CERC-018, Signature with U.S. Environmental Protection Agency. December 9.

Navy, 2006a. Navy Perchlorate Sampling and Management Policy. May 16.

Navy, 2006b. Navy Environmental Restoration Program Manual. August.

Navy, 2010. Navy Perchlorate Release Management Policy. March 3.

NSFIH (Naval Support Facility Indian Head), 2011a. *Wastewater sample result from Building 1018 in September 2006*. Sample collected by NSFIH Environmental Department. Laboratory data report provided via email from NSFIH Environmental on June 14, 2011.

NSFIH, 2011b. Soil Samples for Trident Plant (Building 1018 Area). Samples collected by NSFIH Environmental Department. Data report provided via email from NSFIH Environmental on November 8, 2011.

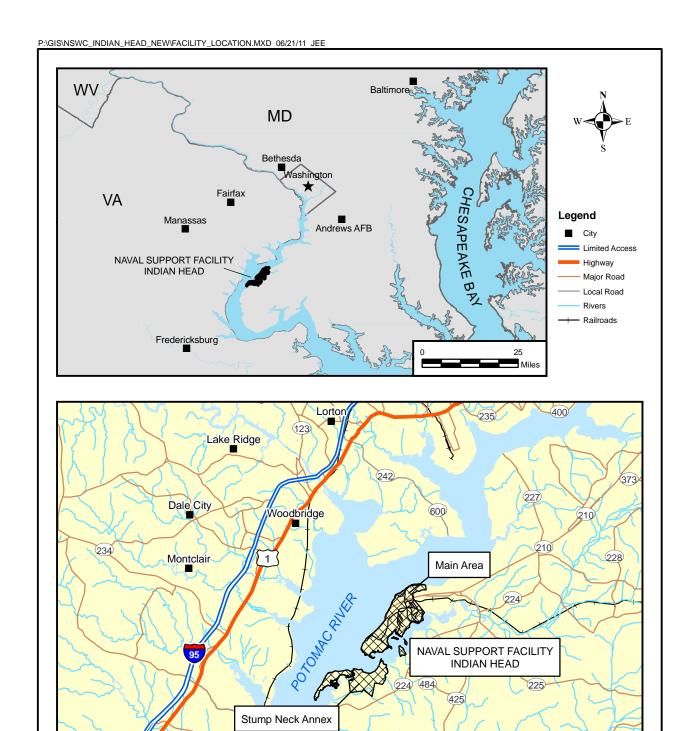
Tt (Tetra Tech), 2002. Background Soil Investigation Report for Indian Head and Stump Neck Annex, Naval Surface Warfare Center, Indian Head, Maryland. October.

Tt, 2009. Master Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) for Installation Restoration Program and Munitions Response Program Environmental Investigations, NSFIH, Indian Head, Maryland. May.

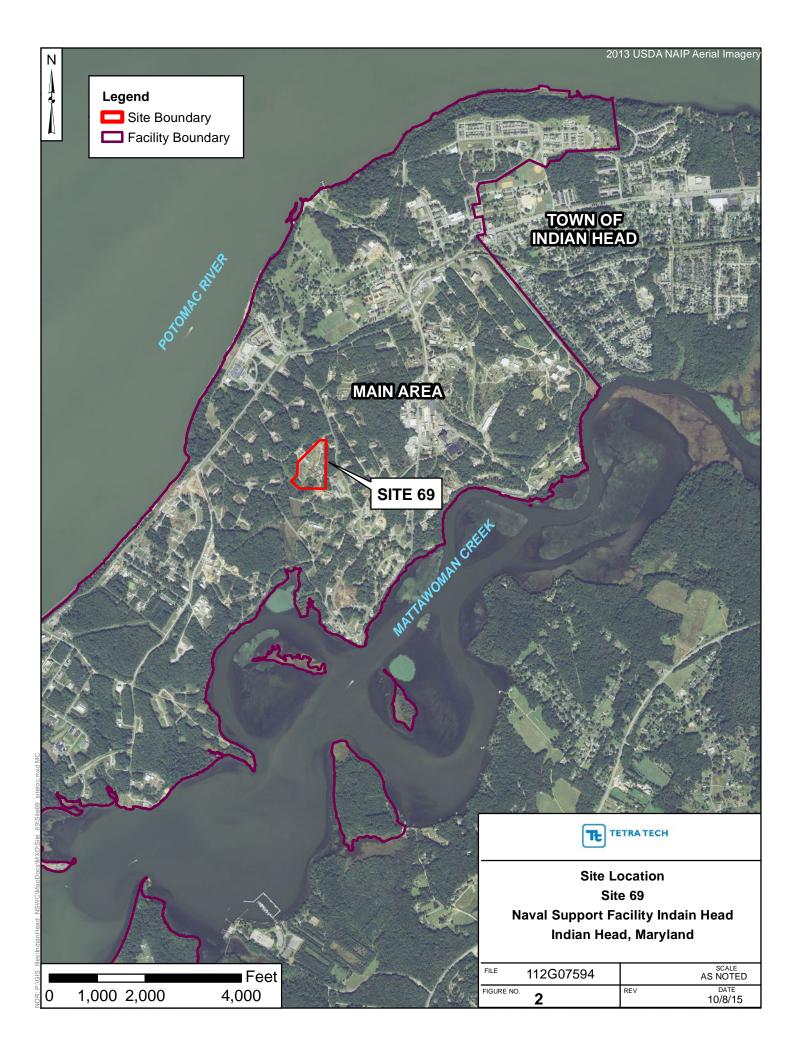
Tt, 2012. Site Management Plan for Installation Restoration Program, Naval Support Facility Indian Head, Indian Head, Maryland, Fiscal Years 2012 to 2013. October.

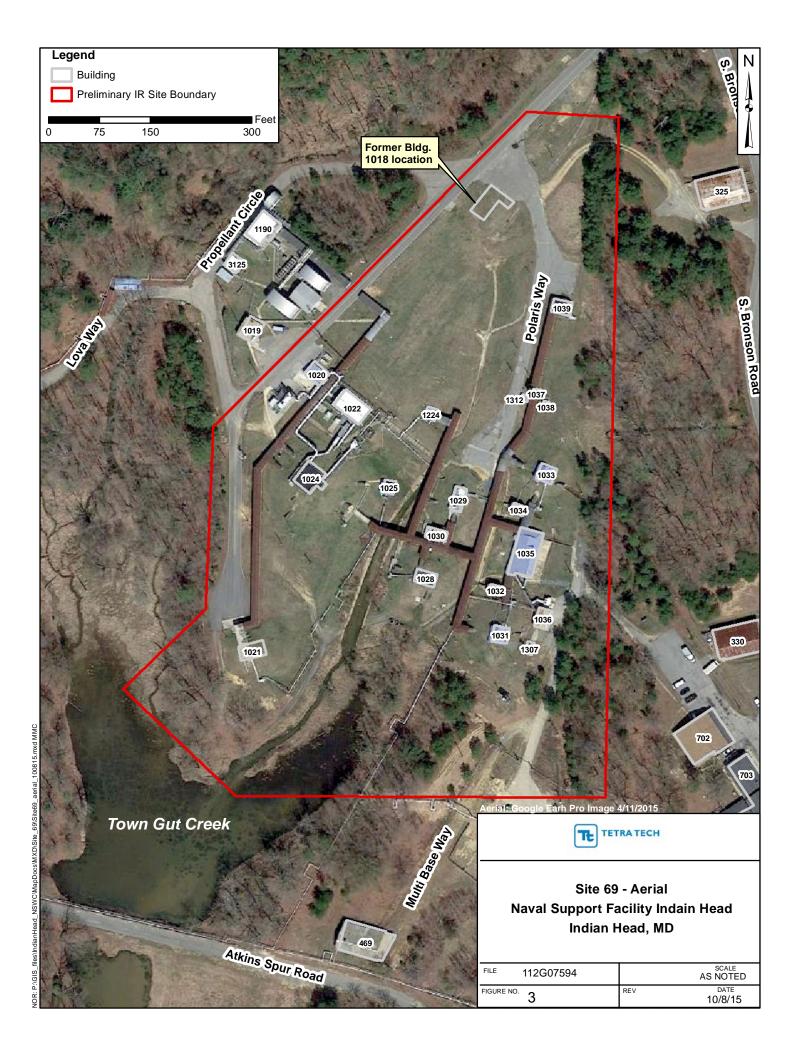
Tt, 2013. Uniform Policy Sampling and Analysis Plan for Site Screening Process Investigation at Site 69 – Building 1018 (Oxidizer Process Building) and AOC 31 – Building 259 (Old Storehouse / Detonator Production), Naval Support Facility Indian Head, Indian Head, Maryland. Navy Tier 2 format UFP-SAP: Field Sampling Plan and Quality Assurance Project Plan. July.

Tt, 2015. Site Screening Process Investigation Report for Site 69 – Building 1018 (Oxidizer Process Building) and AOC 31 – Building 259 (Old Storehouse / Detonator Production), Naval Support Facility Indian Head, Indian Head, Maryland. July.



DRAWN BY	DATE	TE TETRA TECH	CONTRACT NUMBER			
K. MOORE	03/20/09		CTO JU14			
CHECKED BY	DATE	FACILITY LOCATION MAP	APPROVED BY	DATE		
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DRAWN BY J. ENGLISH	DATE 06/21/11	NAVAL SUPPORT FACILITY INDIAN HEAD	APPROVED BY	DATE —		
SCALE AS NOTED		INDIAN HEAD, MARYLAND	FIGURE NO. 1	REV 0		





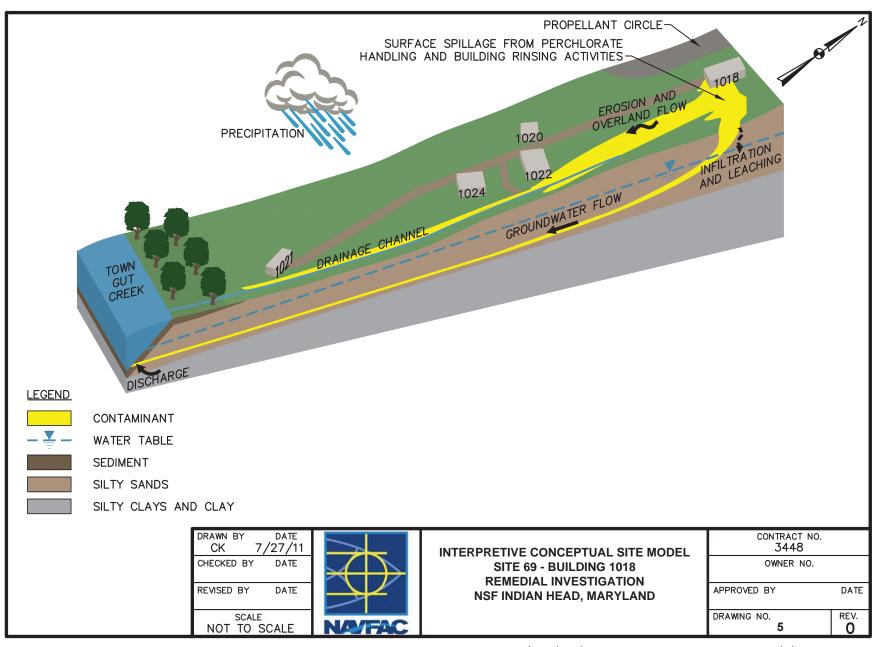


FIGURE 6 HUMAN HEALTH EXPOSURE PATHWAY ANALYSIS SITE 69 - BUILDING 1018 (OXIDIZER PROCESS BUILDING) REMEDIAL INVESTIGATION WORK PLAN NSF INDIAN HEAD, MARYLAND

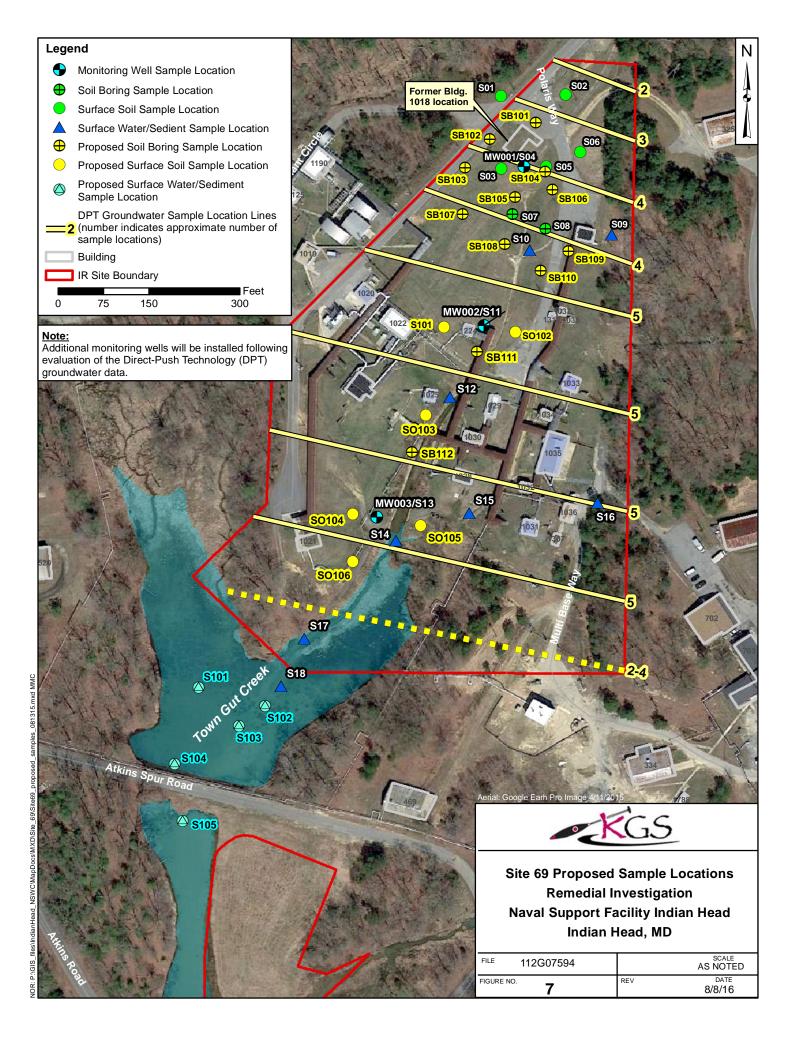
Primary Contaminant Source	Primary Source Release Mechanism	Secondary Source Medium	Secondary Release Mechanisms	Exposure Medium	Exposure Mechanism			Recep	otors	
							Curren	t or Fut	ure Hun	nan Rece
						Military	Contractors	Construction w	Trespassers/	Future Residents
		Surface		Surface Water/	Ingestion of Sediment	•	•	•	•	•
		Water Runoff	Groundwater	Surface water/ Sediment	→ Direct Contact/Uptake	→ •	•	•	•	•
			Discharge	(Creek)	Biouptake/Food Ingestion	0	0	0	•	0
			<u> </u>							<u> </u>
					Ingestion of Groundwater	0	0	•	0	•
Site 69			Infiltration/	Groundwater	➤ Direct Contact/Uptake	→ 0	0	•	0	•
Building 1018	Historical Spills/Release		→ Leaching to		Inhalation (Vapor)	0	0	0	0	0
(Oxidizer Process	onto Ground	Soil	Subsurface Soil and		,	<u> </u>			ļ	
Building)	Surface	<u> </u>	Groundwater —	—	Ingestion of Soil	0	0	•	0	•
				Subsurface Soil	→ Direct Contact/Uptake	→ 0	0	•	0	•
					Inhalation (Dust)	0	0	•	0	•
			Erosion of				l .	<u>l</u>	<u>I</u>	J
			Surface Soil _	—	Ingestion of Soil	•	•	•	•	•
				Surface Soil	Direct Contact/Uptake	•	•	•	•	•
						→				1
					Inhalation (Dust)	•	•	•	•	•

Potentially Complete Pathway

O Incomplete Pathway

Note: The SSP Investigation Report (Tetra Tech, 2015) concluded no unacceptable ecological risk

from exposure to perchlorate in any medium.



Appendix A Historical Data

TABLE 4-1

SOIL RESULTS FOR SITE 69

SITE 69 - BUILDING 1018 (OXIDIZER PROCESS BUILDING) SITE SCREENING PROCESS INVESTIGATION

NSF INDIAN HEAD, MARYLAND

Station ID			S01	S02	S03	S	S05	
Sample ID	EPA	EPA	S69-SS001-0001	S69-SS002-0001	S69-SS003-0001	S69-SS004-0001	S69-SB004-0708	S69-SS005-0001
	Residential	Industrial						
Sample Date	Soil RSL	Soil RSL	7/17/2013	7/17/2013	7/16/2013	7/16/2013	7/16/2013	7/16/2013
Sample Depth (feet bgs)	(HI=1)	(HI=1)	0 - 1	0 - 1	0 - 1	0 - 1	7 - 8	0 - 1
Oxidizer (µg/kg)								
Perchlorate	55,000	820,000	0.99 J	7.2 J	29 J	2,000 J	89,000 J	17 J

Station ID			S06		S07		S08		
Sample ID	EPA	EPA	S69-SS006-0001	S69-SS006P-0001	S69-SS007-0001	S69-SB007-0607	S69-SS008-0001	S69-SB008-0203	
	Residential	Industrial		(duplicate)					
Sample Date	Soil RSL	Soil RSL	7/17/2013	7/17/2013	7/16/2013	7/16/2013	7/16/2013	7/16/2013	
Sample Depth (feet bgs)	(HI=1)	(HI=1)	0 - 1	0 - 1	0 - 1	6 - 7	0 - 1	2 - 3	
Oxidizer (µg/kg)									
Perchlorate	55,000	820,000	0.33 J	0.16 J	150 J	1,200 J	520 J	870 J	

Station ID				S11	S13		
Sample ID	EPA Residential	EPA Industrial	S69-SS011-0001	\$69-\$\$011P-0001 (duplicate)	S69-SB011-0708	S69-SS013-0001	S69-SB013-0708
Sample Date	Soil RSL	Soil RSL	7/16/2013	7/16/2013	7/16/2013	7/17/2013	7/17/2013
Sample Depth (feet bgs)	(HI=1)	(HI=1)	0 - 1	0 - 1	7 - 8	0 - 1	7 - 8
Oxidizer (µg/kg)							
Perchlorate	55,000	820,000	98 J	23 J	3.6 J	92 J	9.2 J

Notes

Bold, shaded value exceeds EPA Residential RSL

μg/kg : microgram(s) per kilogram

EPA RSL - U.S. Environmental Protection Agency Regional Screening Level (June 2015 update). RSLs based on Hazard Index (HI) equal to 1 (not adjusted).

bgs - below ground surface J - Estimated value

TABLE 4-2

MONITORING WELL GROUNDWATER RESULTS FOR SITE 69 SITE 69 - BUILDING 1018 (OXIDIZER PROCESS BUILDING) SITE SCREENING PROCESS INVESTIGATION NSF INDIAN HEAD, MARYLAND

Station ID				MW0	1 (S04)	MW02 (S11)	MW03 (S13)	
Sample ID	EPA			S69-MW001-072313	S69-MW001P-072313	S69-MW002	S69-MW003	
	Tapwater		DoD		(duplicate)			
Sample Date	RSL	Federal	Action	7/23/2013	7/23/2013	7/23/2013	7/23/2013	
Sample Depth (feet bgs) *	(HI=1)	MCL	Level	6 - 16	6 - 16	6 - 16	6 - 16	
Oxidizer (µg/L)								
Perchlorate	14	15	15	55,000	56,000	0.68	4.9	
Wet Chemistry (mg/L)								
Nitrate (as Nitrogen)	32	10	NA	6.3 J	9 J	0.21 J	0.39 J	
Nitrite (as Nitrogen)	2	1	NA	0.12 J	0.21 J	0.017 J	0.025 J	
Water Quality Parameters (Field-Meas	sured)							
pH (S.U.)	NA	NA	NA	4.42	4.42	4.8	3.99	
Specific Conductivity (mS/cm)	NA	NA	NA	1.06	1.06	0.695	6.77	
Dissolved Oxygen (mg/L)	NA	NA	NA	8.78	8.78	6.45	3.3	
 Horiba Water Quality Meter 	INA	INA	INA	0.70	0.70	0.43	ა.ა	
Dissolved Oxygen (mg/L)	NA	NA	NA	7	7	6	2	
 CHEMETRICS Field Test Kit 	INA	INA	INA	′	,	0	2	
Temperature (°C)	NA	NA	NA	20.5	20.5	20.7	22.6	
Oxygen-Reduction Potential (mV)	NA	NA	NA	272	272	184	228	
Turbidity (NTU)	NA	NA	NA	2.7	2.7	2.2	2.4	
Salinity (%)	NA	NA	NA	0.5	0.5	0.3	3.7	
Iron II - Ferrous Iron (ppm)	NIA	NIA	NIA	0	0	0.4	4	
- HACH Field Test Kit	NA	NA	NA	0	0	0.4	1	

NOTES:

Bold, shaded value exceeds EPA Residential RSL

NA - not applicable, not available, or not analyzed

J - estimated value S.U. - standard unit(s) * Sample depth is the monitoring well screen interval depth in feet below ground surface (ft bgs)

μg/L : microgram(s) per liter Specific conductance is the electrical conductivity value standardized to 25°C (degrees Celsius)

mg/L - milligram(s) per liter mS/cm - millisiemen(s) per centimeter; 1 siemen = 1/ohm = mho.

bgs - below ground surface °C - degrees Celsius mV - millivolts ppm - parts per million NTU - Nephelometric Turbidity Unit(s)

Field-measured water quality parameter data collected using Horiba U-52 (or equivalent) water quality meter with flow-through cell, CHEMETRICS field test kit, and HACH field test kit.

Nitrate (as Nitrogen) - Total nitrate (NO₃⁻) reported as total nitrogen (N). The concentration of NO₃⁻ is found by multiplying the concentration as N by the

molecular weight of NO₃ (62.00) and dividing by the atomic weight of N (14.01).

Nitrite (as Nitrogen) - Total nitrite (NQ_2^-) reported as total nitrogen (N). The concentration of NQ_2^- is found by multiplying the concentration as N by the molecular weight of NO2- (46.01) and dividing by the atomic weight of N (14.01).

Federal MCL (Maximum Contaminant Level) - EPA (April 2012) Drinking Water Standards & Health Advisories. EPA 822-S-12-001. Office of Water.

Washington, D.C. For perchlorate, the effective MCL is the EPA Health Advisory Level.

EPA RSL - U.S. Environmental Protection Agency Regional Screening Level (June 2015 update). RSLs based on Hazard Index (HI) equal to 1 (not adjusted).

DoD (Department of Defense) Action Level - DoD (2009) Memorandum: Perchlorate Release Management Policy.

Signed by Deputy Under Secretary of Defense (Installations and Environment) on April 22.

TABLE 4-3 SURFACE WATER RESULTS FOR SITE 69 SITE 69 - BUILDING 1018 (OXIDIZER PROCESS BUILDING) SITE SCREENING PROCESS INVESTIGATION NSF INDIAN HEAD, MARYLAND

Station ID				S09	S12	S14		S15	S17	S18
Sample ID	EPA Tap			S69-SW009-072313	S69-SW012-072313	S69-SW014-071513	S69-SW014P-071513	S69-SW015-071513	S69-SW017-071713	S69-SW018-071713
	Water		DoD				(duplicate)			
Sample Date	RSL	Federal	Action	7/23/13	7/23/13	7/15/2013	7/15/2013	7/15/2013	7/17/2013	7/17/2013
Sample Depth (feet) *	(HI=1)	MCL	Level	At Depth *	At Depth *	At [Depth *	At Depth *	At Depth *	At Depth *
Oxidizer (µg/L)										
Perchlorate	14	15	15	0.091 J	23	18	18	0.76	19	19
Wet Chemistry (mg/L)										
Nitrate (as Nitrogen)	32	10	NA	NA	NA	0.6	0.6	0.025 U	0.62	0.51
Nitrite (as Nitrogen)	2	1	NA	NA	NA	0.01 J	0.011 J	0.025 J	0.01 J	0.012 J
Water Quality Parameters (Field-Mea	sured)									
pH (S.U.)	NA	NA	NA	7.45	7.15	6.13	6.13	7.67	8.81	9.43
Specific Conductivity (mS/cm)	NA	NA	NA	0.806	0.394	0.476	0.476	0.234	0.371	0.385
Dissolved Oxygen (mg/L) - Horiba Water Quality Meter	NA	NA	NA	5.02	8.03	4.51	4.51	6.25	7.08	9.01
Dissolved Oxygen (mg/L) - CHEMETRICS Field Test Kit	NA	NA	NA	NA	NA	5	5	5	NA	NA
Temperature (°C)	NA	NA	NA	26.8	25.7	33.7	33.7	37.5	33.1	33.6
Oxygen-Reduction Potential (mV)	NA	NA	NA	127	92	48	48	96	169	154
Turbidity (NTU)	NA	NA	NA	226	6.6	704	704	139	37.1	29
Salinity (%)	NA	NA	NA	0.4	0.2	0.2	0.2	0.1	0.2	0.2
Iron II - Ferrous Iron (ppm) - HACH Field Test Kit	NA	NA	NA	NA	NA	0	0	0.2	NA	NA

NOTES:

Bold, shaded value exceeds EPA Tapwater RSL NA - not applicable, not available, or not analyzed

J - estimated value U - not detected S.U. - standard unit(s) * At Depth - surface water samples were collected at the bottom of the water column above the sediment surface.

µg/L : microgram(s) per liter Specific conductance is the electrical conductivity value standardized to 25°C (degrees Celsius)

mg/L - milligram(s) per liter mS/cm - millisiemen(s) per centimeter; 1 siemen = 1/ohm = mho.

bgs - below ground surface °C - degrees Celsius mV - millivolt(s) ppm - part(s) per million NTU - Nephelometric Turbidity Unit(s)
Field-measured water quality parameter data collected using Horiba U-52 (or equivalent) water quality meter with flow-through cell, CHEMETRICS field test kit, and HACH field test kit.

Nitrate (as Nitrogen) - Total nitrate (NO3) reported as total nitrogen (N). The concentration of NO3 is found by multiplying the concentration as N by the molecular weight of NO3 (62.00) and dividing by the atomic weight of N (14.01).

Nitrite (as Nitrogen) - Total nitrite (NO2) reported as total nitrogen (N). The concentration of NO2 is found by multiplying the concentration as N by the molecular weight of NO2- (46.01) and dividing by the atomic weight of N (14.01).

Federal MCL (Maximum Contaminant Level) - EPA (April 2012) Drinking Water Standards & Health Advisories. EPA 822-S-12-001. Office of Water. Washington, D.C. For perchlorate, the effective MCL is the EPA Health Advisory Level.

EPA RSL - U.S. Environmental Protection Agency Regional Screening Level (June 2015 update). RSLs based on Hazard Index (HI) equal to 1 (not adjusted).

DoD (Department of Defense) Action Level - DoD (2009) Memorandum: Perchlorate Release Management Policy. Signed by Deputy Under Secretary of Defense (Installations and Environment) on April 22.

No surface water was available at location S10 during the SSP Investigation.

TABLE 4-4 SEDIMENT RESULTS FOR SITE 69 SITE 69 - BUILDING 1018 (OXIDIZER PROCESS BUILDING) SITE SCREENING PROCESS INVESTIGATION NSF INDIAN HEAD, MARYLAND

Station ID			S09	S14		S15	S16	S17	S18
Sample ID	EPA	EPA	S69-SD009-0001		S69-SD014P-0001				
	Residential	Industrial		S69-SD014-0001	(duplicate)	S69-SD015-0001	S69-SD016-0001	S69-SD017-0001	S69-SD018-0001
Sample Date	Soil RSL	Soil RSL	7/23/2013	7/15/2013	7/15/2013	7/15/2013	7/15/2013	7/17/2013	7/17/2013
Sample Depth (feet) *	(HI=1)	(HI=1)	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1
Oxidizer (µg/kg)									
Perchlorate	55,000	820,000	0.53 U	0.36 U	0.38 U	0.41 UR	0.25 U	0.4 UJ	0.38 UJ

Notes:

No exceedances of EPA Residential RSL in sediment samples.

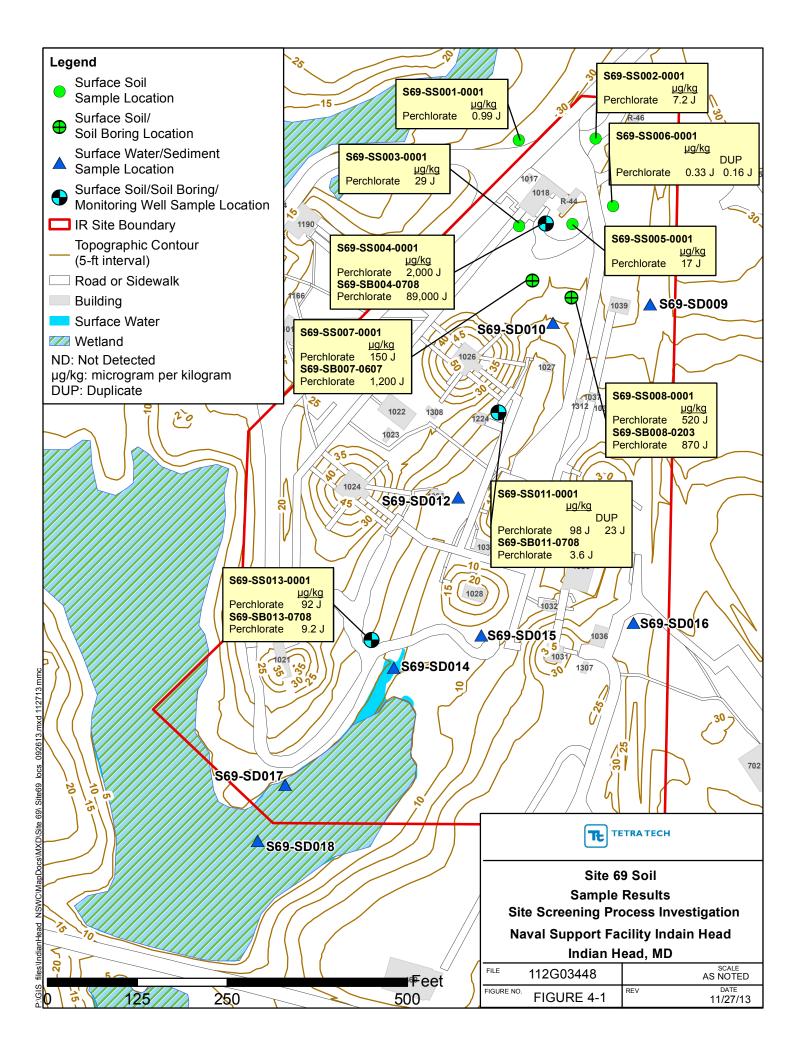
μg/kg : micrograms per kilogram

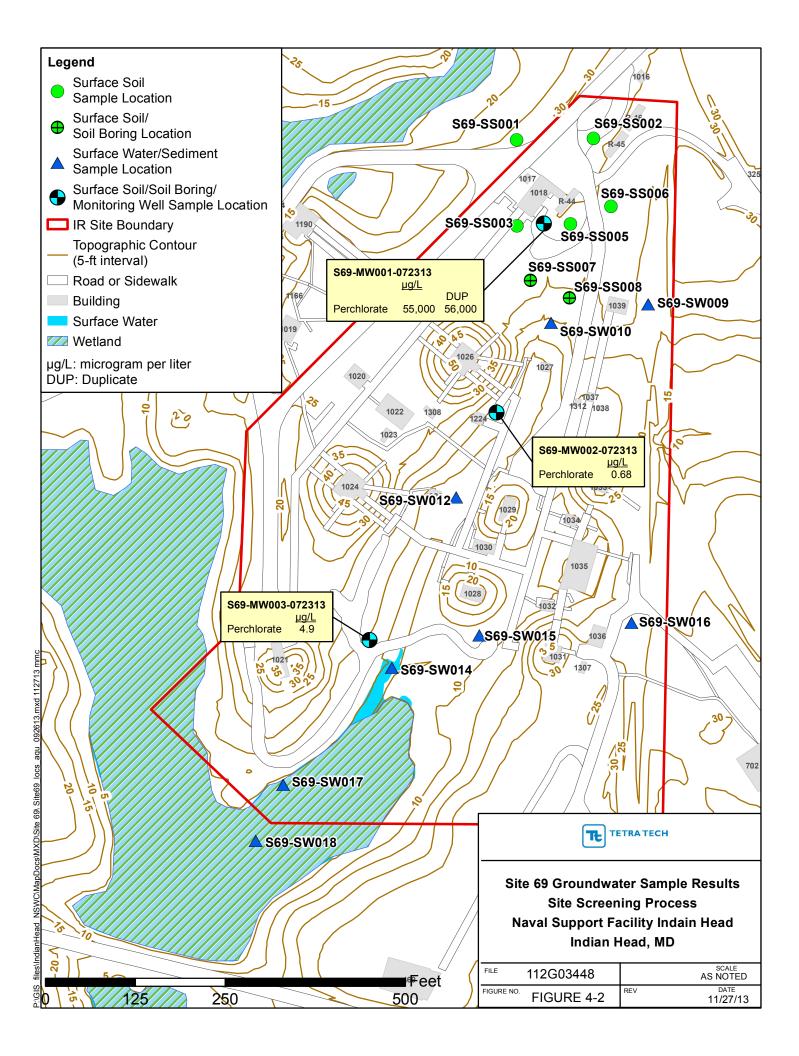
EPA RSL - U.S. Environmental Protection Agency Regional Screening Level (June 2015 update). RSLs based on Hazard Index (HI) equal to 1 (not adjusted).

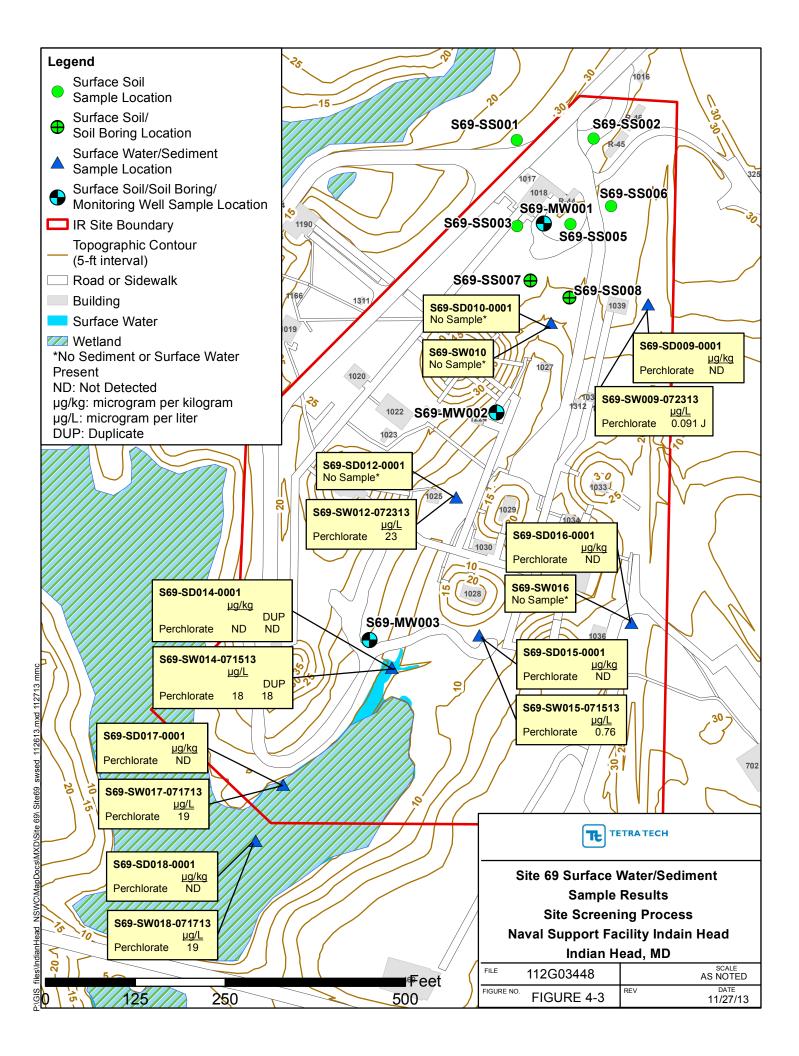
- * Sediment sample depth measured in feet below sediment surface
- J Estimated value
- U Not detected

R - rejected; unusable. Value was rejected by data validator due to laboratory surragate recovery noncompliance.

No sediment was available at location S10 during the SSP Investigation.







Appendix B Fieldwork SOPs

STANDARD OPERATING PROCEDURES

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Effective Date	Revision
02/04	0

Subject

SAMPLE NOMENCLATURE

Approved

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1.0 PURPOSE

The purpose of this document is to specify a consistent sample nomenclature system that will facilitate subsequent data management in a cost-effective manner. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix.
- Sorting of data by depth.
- Maintenance of consistency (field, laboratory, and data base sample numbers).
- Accommodation of all project-specific requirements.
- Accommodation of laboratory sample number length constraints (maximum of 20 characters).

2.0 SCOPE

The methods described in this procedure shall be used consistently for all projects requiring electronic data.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

<u>Program Manager</u> - It shall be the responsibility of the Program Manager (or designee) to inform contractspecific Project Managers of the existence and requirements of this Standard Operating Procedure.

<u>Project Manager</u> - It shall be the responsibility of the Project Manager to determine the applicability of this Standard Operating Procedure based on: (1) program-specific requirements, and (2) project size and objectives. It shall be the responsibility of the Project Manager (or designee) to ensure that the sample nomenclature is thoroughly specified in the relevant project planning document (e.g., sampling and analysis plan) and is consistent with this Standard Operating Procedure if relevant. It shall be the responsibility of the project manager to ensure that the Field Operations Leader is familiar with the sample nomenclature system.

<u>Field Operations Leader</u> - It shall be the responsibility of the Field Operations Leader to ensure that all field technicians or sampling personnel are thoroughly familiar with this Standard Operating Procedure and the project-specific sample nomenclature system. It shall be the responsibility of the Field Operations Leader to ensure that the sample nomenclature system is used during all project-specific sampling efforts.

5.0 PROCEDURES

5.1 Introduction

The sample identification (ID) system can consist of as few as 8 but not more than 20 distinct alphanumeric characters. The sample ID will be provided to the laboratory on the sample labels and chain-of-custody forms. The basic sample ID provided to the lab has three segments and shall be as follows where "A" indicates "alpha," and "N" indicates "numeric":

A or N	AAA	A or N
3- or 4-Characters	2- or 3-Characters	3- to 6-Characters
Site Identifier	Sample Type	Sample Location

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Additional segments may be added as needed. For example:

See Sample Details Table on Worksheet 8 for specified sample IDs for this project.

(1) Soil and Sediment Sample ID

A or N	AAA	A or N	NNNN
3- or 4-Characters	2- or 3-Characters	3- to 6-Characters	4-Characters
Site Identifier	Sample Type	Sample Location	Sample Depth

(2) Aqueous (groundwater or surface water) Sample ID

NNNNNN Sample Date

A or N	AAA	A or N	NN	
3- or 4-Characters	2- or 3-Characters	3- to 6-Characters	2-Characters	
Site Identifier	Sample type	Sample Location	Round Number	Filtered Sample only

(3) Biota Sample ID

A or N	AAA	A or N 3- to 6-Characters	AA	NNN
3- or 4-Characters	2- or 3-Characters		2-Characters	3-Characters
Site Identifier	Sample T ype	Sample Location	Species Identifier	Sample Group Number

5.2 Sample Identification Field Requirements

The various fields in the sample ID will include but are not limited to the following:

- Site Identifier
- Sample Type
- Sample Location
- Sample Depth
- Sampling Round Number
- Filtered
- Species Identifier
- Sample Group Number

The site identifier must be a three- or four-character field (numeric characters, alpha characters, or a mixture of alpha and numeric characters may be used). A site number is necessary since many facilities/sites have multiple individual sites, SWMUs, operable units, etc. Several examples are presented in Section 5.3 of this SOP.

The sample type must be a two- or three-character alpha field. Suggested codes are provided in Section 5.3 of this SOP.

The sample location must be at least a three-character field but may have up to six-characters (alpha, numeric, or a mixture). The six-characters may be useful in identifying a monitoring well to be sampled or describing a grid location.

The sample depth field is used to note the depth below ground surface (bgs) at which a soil or sediment sample is collected. The first two numbers of the four-number code specify the top interval, and the third and fourth specify the bottom interval in feet bgs of the sample. If the sample depth is equal to or greater than 100, then only the top interval would be represented and the sampling depth would be truncated to

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three-characters. The depths will be noted in whole numbers only; further detail, if needed, will be recorded on the sample log sheet, boring log, logbook, etc.

A two-digit round numb aqueous sample location 01, the second 02, etc locations.

Date in MMDDYY format distinguishes 'sample

ken from a particular ed the round identifier ells and surface water

Aqueous samples that segment. No entry in t

Filtered samples have same sample ID as parent

" in the last field

The species identifier must be a two-character alpha field. Several suggested codes are provided in Section 5.3 of this SOP.

The three digit sample group number will be used to track the number of biota sample groups (a particular group size may be determined by sample technique, media type, the number of individual caught, weight issues, time, etc.) by species and location. The first sample group of a particular species collected from a given location will be assigned the sample group number 001 and the second sample group of the same species collected from the same location will be assigned the sample group number 002.

5.3 **Example Sample Field Designations**

rounds.'

Examples of each of the fields are as follows:

Site Identifier - Examples of site numbers/designations are as follows:

A01 -Area of Concern Number 1

125 -Solid Waste Management Unit Number 125

000 -Base or Facility Wide Sample (e.g., upgradient well)

BBG -Base Background

The examples cited are only suggestions. Each Project Manager (or designee) must designate appropriate (and consistent) site designations for their individual project.

Sample Type - Examples of sample types are as follows:

AH -Ash Sample

AS Air Sample

BM -**Building Material Sample**

BSB -Biota Sample Full Body

BSF -Biota Sample Fillet

CP -Composite Sample

CS Chip Sample

DS -Drum Sample

DU -**Dust Sample**

Free Product FP

IDW -Investigation Derived Waste Sample

LT Leachate Sample

MW -Monitoring Well Groundwater Sample

Outfall Sample OF

RW -Residential Well Sample

SB Soil Boring Sample

SD Sediment Sample

SC Scrape Sample

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SG -Soil Gas Sample Sludge Sample SL SP -Seep Sample

SS Surface Soil Sample

ST Storm Sewer Water Sample

SW -Surface Water Sample

TP Test Pit Sample

Temporary Well Sample TW -

WC -Well Construction Material Sample

WP -Wipe Sample Waste/Solid Sample WS ww -Wastewater Sample

Sample Location - Examples of the location field are as follows:

Monitoring Well 1 001

N32E92 Grid location 32 North and 92 East

D096 Investigation derived waste drum number 96

Species Identifier - Examples of species identifier are as follows:

BC Blue Crab GB Blue Gill CO Corn SB Soybean

5.4 **Examples of Sample Nomenclature**

The first round monitoring well groundwater sample collected from existing monitoring well 001 at SWMU 16 for a filtered sample would be designated as 016MW00101-F.

The second round monitoring well groundwater sample collected from existing monitoring well C20P2 at Site 23 for an unfiltered sample would be designated as 023MWC20P202.

The second surface water sample collected from point 01 at SWMU 130 for an unfiltered sample would be designated as 130SW00102.

A surface soil sample collected from grid location 32 North and 92 East at Site 32 at the 0- to 2-foot interval would be designated as 032SSN32E920002.

A subsurface soil sample from soil boring 03 at SWMU 32 at an interval of 4 to 5 feet bgs would be designated as 032SB0030405.

A sediment sample collected at SWMU 19 from 0 to 6 inches at location 14 would be designated as 019SD0140001. The sample data sheet would reflect the precise depth at which this sample was collected.

During biota sampling for full body analysis the first time a minnow trap was checked at grid location A25 of SWMU 1415 three small blue gills were captured, collected and designated with the sample ID of 1415BSBA25BG001. The second time blue gill were collected at the same location (grid location A25 at SWMU 1415) the sample ID designation given was 1415BSBA25BG002.

Note: No dash (-) or spacing is used between the segments with the exception of the filtered segment. The "F" used for a filtered aqueous sample is preceded by a dash "-F".

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5.5 Field Quality Assurance/Quality Control (QA/QC) Sample Nomenclature

Field QA/QC will be designated using a different coding system. The QC code will consist of a three- to four-segment alpha-numeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

A or N	AA	NNNNN	NN	- F
Site	QC Type	Date	Sequence Number	Filtered
Identifier			(per day)	(aqueous only, if needed)

The QC types are identified as:

TB = Trip Blank

EB RB = Rinsate Blank (Equipment Blank)

FD = Field Duplicate

AB = Ambient Conditions Blank

WB = Source Water Blank

Add "P" after sample location in sample ID to indicate field duplicate at that location

The sampling time recorded on the Chain-of-Custody Form, labels, and tags for duplicate samples will be 0000 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the routine sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory). Documentation for all other QC types (TB, RB, AB, and WB) will be recorded on the QC Sample Log sheet (see SOP on Field Documentation).

5.6 **Examples of Field QA/QC Sample Nomenclature**

The first duplicate of the day for a filtered ground \Duplicate of groundwater sample designated as FD06030001-F.

The third duplicate of the day taken of a subsurface so November 17, 2001, would be designated as FD11170303.

The first trie blank associated with samples collect TB10120001.

collected from well MW01 on designated as S67-MW01P-111701

buid be

buld be

ited as

6.0 **DEVIATIONS**

The only rinsate blank collected on November 17, 2001 would be designated as RB11170101. S67-EB01-111701

Any deviation from this SOP must be addressed in detail in the site specific planning documents.

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1.0 PURPOSE

The purpose of a site reconnaissance is to collect both general and technical information which will support the scoping, scheduling, implementing project activities, and writing reports for an environmental investigation. This procedure is not intended as a guide for Phase I investigations or for Environmental Baseline Survey activities.

2.0 SCOPE

This procedure is applicable to the performance of a site reconnaissance for initial site characterization. The steps necessary to develop and carry out a site reconnaissance are presented here. These steps include a list of equipment and items which may be needed, areas of special interest during field observations, and methods by which the field observation team can ensure that necessary and appropriate observations have been made.

3.0 GLOSSARY

<u>Site reconnaissance</u>. An onsite inspection program used to identify site-specific conditions that control scheduling, manpower, and affect costs. A site reconnaissance usually consists of visual observations and, often, the use of field monitoring instruments to identify potential health and safety threats and potential sampling locations for site evaluation during subsequent field investigations.

4.0 RESPONSIBILITIES

<u>Field Operations Leader (FOL)</u> is responsible for ensuring that the survey is carried out in sufficient detail. To accomplish this, the FOL must assign the proper personnel and equipment to characterize the site adequately, in accordance with the requirements defined in this procedure and best engineering practices. Other disciplines which may be applicable include (but are not limited to): Geology/Hydrogeology; Health and Safety; Ecological Specialists; and/or Engineering. In addition, the FOL is responsible for supervising equipment preparation, including necessary calibrations, and supervising field data collection and documentation in accordance with the methods described in all referenced standard operation procedures.

Project Manager is responsible for the following:

- Supervising the retrieval and examination of available, applicable information regarding the site.
- Obtaining appropriate program approvals and ensuring the preparation of a site Health and Safety plan for the site reconnaissance.
- Coordinating the field activities with facility personnel and other Navy and regulatory personnel, as applicable.

<u>Field Personnel</u> are primarily responsible for observing and documenting, either through written documentation or photographic evidence, the site reconnaissance. Field personnel will take direction from the FOL.

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5.0 PROCEDURES

5.1 Equipment Items/Needed

Below is a list of items that may be useful when conducting a site reconnaissance. All, or a portion of these items may be required, depending upon the objective of the site reconnaissance.

- Health and Safety equipment and information as required by the Site Safety Officer.
- Maps (U.S.G.S. quadrangle, geologic maps, street and highway maps, and client facility maps).
- Geologic tools (compass, tape measure, hand level, digital camera, etc.).
- Physical monitoring equipment, if applicable (PID, Immunoassay Test Kits, etc.)
- Regional publications (U.S.G.S reports, water well surveys, U.S.D.A. soil conservation surveys, etc.).
- Site-specific publications by previous investigators (EPA aerial photographic analyses, remedial investigation reports, data on waste disposal practices, boring logs, etc.).
- Marking items (ink markers, surveyor's flagging, spray paint, pin flags, wooden stakes).
- Field notebooks.
- Local telephone book with yellow pages (for obtaining utilities, site trailer, living accommodations, etc.).

Sufficient time will be required in order to obtain some of the aforementioned material. In general, most publications can be obtained in time to be used in the site reconnaissance if ordered approximately 2 weeks before the actual site visit takes place.

5.2 Observations

A site reconnaissance usually requires one to two days, however, additional time may be needed depending upon the objective, site size, etc. The following observations, when applicable, should be documented either on a site map, field notebook, or photographed.

- General Site Access. It should be noted whether site roads provide access to all proposed work locations, or if it will be necessary to prepare access roads with either a backhoe, dozer, chain saws, etc., in order to get drill rigs, excavators, or other work vehicles to specific locations. If temporary driveways must be constructed from existing public roads, regulatory permits may be required. Military facilities may have specific security requirements which require detailed clearance procedures.
- Location of the Command Post or Site Trailer and Sanitary Facilities. The ideal location for the site trailer and sanitary facilities is a level area, within an uncontaminated zone, and centralized in order to provide easy access to work areas on the site. However, certain utility companies may require that the site trailer be placed within a specified radius (usually 100 feet), of the nearest utility pole. Contact the necessary utility companies and inquire about the requirements regarding service before conducting the site reconnaissance. Information that may be required by the utility companies is: type of electric service needed (inquire with trailer vendor for this information); and utility pole number of interest (pole numbers are usually stamped on a brass plate on the pole).

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- <u>Potable Water Sources</u>. Local fire departments may allow access to fire hydrants. Private water delivery companies may also be available in the area.
- Sources of Possible Contamination. Drums, tanks, sludge areas, areas of stressed vegetation, fill
 areas, and leachate seeps may indicate where sources of contamination exist. Filler pipes protruding
 from the ground surface may indicate the presence of underground storage tanks. Areas where the
 original ground surface has been reworked may be contaminated fill areas that have since been
 buried and covered with natural material. Previous environmental investigations may also identify
 source areas.
- <u>Location of Decon Areas and Storage/Disposal Areas for Equipment and Wastes Generated by Field</u>
 Activities.
- Locations of Surface Water Bodies. The locations of surface water bodies, both man-made and natural, and their relation to topographic highs may give an indication of the groundwater flow direction in the area (groundwater flow typically follows topography with the topographic highs serving as groundwater recharge areas, and the surface waters at topographic lows serve as groundwater discharge areas). Visible signs of contamination, the existence of aquatic life, flow rates, and approximate levels should also be observed and noted. Check if the surface water bodies could potentially be impacted by field activities. If so, appropriate sedimentation and erosion controls will be required.
- Existing Wells. Existing monitoring wells, or domestic wells within the site and off site, should be noted on a map, and access checked to see if the wells can be used for data collection.
- Outcrops. Outcrops can be useful in providing hydrogeologic data (lithologic description, strike and dip information, fracture and joint system analysis, identification of moist zones, etc.) Outcrops may occur naturally or be a part of a man-made feature such as a road-cut.
- <u>Lineaments</u>. A lineament is a straight lengthy feature on the earth's surface which is expressed topographically as a line of depression. Stream beds, vegetation patterns or soil characteristics may be aligned or controlled by this feature. Lineaments are due in some cases to the presence of intense jointing or faults beneath the ground surface. Groundwater in the bedrock may follow lineaments. Lineaments should be noted on site maps and described in the field notebooks.
- Bench or Property Markers. Benchmarks or property markers should be marked with paint or surveyor's flagging if encountered during a site reconnaissance. Surveyors may need to use these markers as a reference point when surveying. Benchmarks are typically a brass plate secured in concrete in the ground with numbering on the top. Property markers can range from a stake driven into the ground to a rock protruding from the ground surface. Facility contacts may also be aware of local benchmarks used during the course of other environmental or public work projects.
- Metal Cultural Effects. Overhead power lines, railroad tracks, junk automobiles, fences, etc. will
 greatly affect certain geophysical surveys. These features should be noted while conducting a site
 reconnaissance.

6.0 RECORDS

The data collected during a site reconnaissance will be compiled into a trip report when returning from the field. This trip report can then be distributed to the project team. A site reconnaissance checklist is located in Attachment A which can be copied and used while conducting the site reconnaissance.

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ATTACHMENT A

SITE RECONNAISSANCE CHECKLIST

SITE SKETCH

Include the following as appropriate:

- Site name
- Site location
- Site boundaries
- Entrance locations
- Access roads and security requirements
- Disposal locations
- Storage areas
- Office areas
- Well locations
- Treatment facility locations
- Surface drainage, outcrops, general topography descriptions
- Cultural interferences
- Fences
- Aboveground utilities

CHEMICAL STORAGE FACILITIES DESCRIPTION

- Storage tanks numbers, volumes, condition, contents, etc.
- Drums number, conditions, labeling, etc.
- Lagoons and surface pits number, size, use of liner, contents, etc.

TREATMENT SYSTEMS

Note the presence of any treatment systems. These can be difficult to evaluate visually. One should appraise general appearance, maintenance and visual integrity; ask operators for any monitoring records; note presence of odors; and visually characterize any effluents or residues. Describe type of wastes and volumes treated.

- Incinerators
- Flocculation/filtration
- Chemical/physical treatment
- Biological treatment
- Volume reduction
- Waste recycling
- Compositing
- Other

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DISPOSAL FACILITIES

Note the presence and use of any of the following operations. Include a description of the size, use of liners, soil type, and the presence of leachate. Provide a description of management practices. Interview site workers if possible. Describe waste types.

- Landfills
- Land forms
- Open dump
- Surface impoundment
- Underground injection
- Incineration

Also, records for disposal of concentrated/containerized waste should be reviewed.

HAZARDOUS SUBSTANCE CHARACTERISTICS

Ask facility contacts for manifests, inventories, or monitoring reports. Note markings on containers.

- Chemical identities
- Quantities
- Hazard characteristics (toxic, explosive, flammable, etc.)
- Container markings
- · Monitoring data, other analytical data
- Physical state (liquid, solid, gas, sludge)

CHEMICAL PROCESS INFORMATION

- Manufacturing processes and chemicals
- Off-specification or by-product disposal processes
- Housekeeping practices
- Locations of plant operations

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HYDROGEOLOGIC ASSESSMENT

Look for situations that promote hazardous substance migration, i.e., porous soils, fractured bedrock formations, shallow water table and karst features.

- Soil type
- Surface water features
- Surface drainage pattern
- Outcrop studies
- Water wells (use, water depth, and construction details)
- Erosion potential
- Flooding potential
- Climatology

IDENTIFICATION OF SENSITIVE RECEPTORS

- Number and locations of private homes
- Public buildings including tenant usage
- Areas of dead or dying vegetation or animals
- Presence of sensitive ecosystems (wetlands, tidal marshes, etc.)
- Other public use areas (roads, parks, etc.)
- Natural areas

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1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating the physical condition and project utility of existing monitoring wells and determining water levels.

2.0 SCOPE

The procedures described herein are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

<u>Water Table</u> - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

4.0 RESPONSIBILITIES

<u>Site Geologist/Hydrogeologist</u> - Has overall responsibility for the evaluation of existing wells, obtaining water level measurements and developing groundwater contour maps. The site geologist/hydrogeologist (in concurrence with the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number and location of data points which shall be used for constructing a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

<u>Field Personnel</u> - Must have a basic familiarity with the equipment and procedures involved in obtaining water levels and must be aware of any project-specific requirements or objectives.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrogeology.
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths.
- Satisfactory methods of groundwater sampling and analysis to meet the project data quality objectives (DQOs).
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

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5.1 **Preliminary Evaluation**

A necessary first step in evaluating existing monitoring well data is the study and review of the original work plan for monitoring well installation (if available). This helps to familiarize the site geologist/hydrogeologist with site-specific condition, and will promote an understanding of the original purpose of the monitoring wells.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology, and will help to establish consistency between hydraulic properties of the well and physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates, the distance from prominent site features, or the location of the well on a map.
- The installation dates, drilling methods, well development methods, past sampling dates, and drilling contractors.
- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-barrel sampling) may be used to estimate bedrock interface.
- The soil profile and stratigraphy.
- The borehole depth and diameter.
- The elevation of the top of the protective casing, the top of the well riser, and the ground surface.
- The total depth of the well.
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval.
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size.

5.2 <u>Field Inspection</u>

During the onsite inspection of existing monitoring wells, features to be noted include:

- The condition of the protective casing, cap and lock.
- The condition of the cement seal surrounding the protective casing.
- The presence of depressions or standing water around the casing.
- The presence of and condition of dedicated sampling equipment.
- The presence of a survey mark (e.g., a notch) on the inner well casing.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results unless the time when leakage started can be precisely determined.

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these occurrences may invalidate

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previously-collected water quality data. If the monitoring well is to be used in the future, considerations shown in the steps described above should be rectified to rehabilitate the well.

After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a photoionization detector (PID) or flame-ionization detector (FID) to determine the appropriate worker safety level. The following information should be noted:

- Cap function.
- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.
- Presence of a riser cap, method of attachment to casing, and venting of the riser.
- Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.

The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. This includes the determination of static water levels, total well depth and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present and/or the well has not been sampled in 12 or more months, it should be redeveloped before sampling.

Lastly, as a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

See Attachment A, Monitoring Well Inspection Sheet.

5.3 Water Level (Hydraulic Head) Measurements

5.3.1 General

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well purging or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the site geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark (e.g., a notch) on the upper edge of the inner well casing. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells, if necessary.

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Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater, if required.

Water level readings shall be taken regularly, as required by the site geologist/hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due to weather changes.

5.3.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the site geologist/hydrogeologist.

In most instances, preparation of accurate potentiometric surface maps requires that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, electrical water level indicator methods have been found to be best, and thus should be utilized whenever possible when precision is required (e.g., synoptic water level measurements for defining potentiometric surfaces). Other, less precise methods, such as the popper or bell sound, or bailer line methods, should be avoided when precision is required, but may be suitable when used to establish approximate water depths for purging and sampling purposes. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use a pressure transducer.

5.3.3 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

- 1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment, as required. Never remove an air-tight lock (such as a J-plug) with your face over the well. Pressure changes within the well may explosively force the cap off once loosened.
- 2. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B):
 - Well number.
 - Water level (to the nearest 0.01 foot). Water levels shall be taken from the surveyed reference mark (e.g., notch) on the top edge of the inner well casing. If the J-plug was on the well very tightly, it may take several minutes for the water level to stabilize.
 - Time and day of the measurement.
 - Thickness of free product if present.

Water level measuring devices with permanently marked intervals shall be used. The devices shall be free of kinks or folds which will affect the ability of the equipment to hang straight in the well pipe.

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5.3.4 Water Level Measuring Devices

Electric Water Level Indicators

These are the most commonly used devices and consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well adjacent to the survey mark on the inner well casing. The electric tape is read (to the nearest 0.01 ft.) at the measuring point and recorded where contact with the water surface was indicated.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollew on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

5.3.5 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

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5.3.6 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells. See Section 5.4 regarding decontamination of water level measuring equipment. Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy and any adjustments/corrections shall be recorded in the field logbook/notebook. After the corrections/adjustments are made to the measuring device and entered in the field logbook/notebook, the corrected readings shall be entered onto the Groundwater Level Measurement Sheet (Attachment B). Elevations will be entered on the sheet when they become available.

5.4 <u>Equipment Decontamination</u>

All portions of a device which projects down the well casing must be decontaminated prior to advancing to the next well. Manufacturer's instructions for equipment decontamination should be followed. Variations from the manufacturer's requirements may be implemented based on the project objectives, but they must be defined prior to conducting any field activities. Consult the project planning documents and SA-7.1 Decontamination of Field Equipment.

5.5 <u>Health and Safety Considerations</u>

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a health/safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone concentrations using a PID or FID shall be performed to determine required levels of protection. Under certain conditions, airtight well caps may explosively fly off the well when the pressure is relieved. Never stand directly over a well when uncapping it.

6.0 RECORDS

A record of all field procedures, tests and observations must be recorded in the site logbook or designated field notebook. Entries in the log/notebook should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.

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ATTACHMENT B GROUNDWATER LEVEL MEASUREMENT SHEET

Tetra Tech NUS, Inc. GROUNDWATER LEVEL MEASUREMENT SHEET						
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Applicability

Prepared

Subject

SOIL AND ROCK DRILLING METHODS

Approved

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1.0 PURPOSE

The purpose of this procedure is to describe the methods and equipment necessary to perform soil and rock borings and identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits, and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

The sampling methods described within this procedure are applicable to collecting surface and subsurface soil samples, and obtaining rock core samples for lithologic and hydrogeologic evaluation, excavation/foundation design, remedial alternative design and related civil engineering purposes.

3.0 GLOSSARY

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

<u>Wire-Line Coring</u> - As an alternative to conventional coring, this technique is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique, the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.

4.0 RESPONSIBILITIES

<u>Project Manager</u> - In consultation with the project geologist, the Project Manager is responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and the known or suspected geologic conditions at the site. The Project Manager also determines the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

<u>Field Operations Leader (FOL)</u> - The FOL is responsible for the overall supervision and scheduling of drilling activities, and is strongly supported by the project geologist.

<u>Project Geologist</u> - The project geologist is responsible for ensuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see SOPs SA-6.3 and GH-1.5). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan and/or Sampling and Analysis Plan.

<u>Drilling Subcontractor</u> - Operates under the supervision of the FOL. Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to

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perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the FOL within 24 hours of determination, and must provide advance written notification of any changes in field procedures, describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the FOL (with the concurrence of the Project Manager). Depending on the subcontract, the Project Manager may need to obtain written authorization from appropriate administrative personnel before approving any changes.

The drilling subcontractor is responsible for following decontamination procedures specified in the project plan documents. Upon completion of the work, the driller is responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 General

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site.
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned between samples and borings using appropriate decontamination procedures as outlined in SOP SA-7.1. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the site geologist as they proceed (see SOPs SA-6.3 and GH-1.5). Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the site geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 Drilling Methods

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, the waste conditions at the site, and reviewing the purpose of drilling and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

5.2.1 Hollow-Stem Auger Drilling

This method of drilling consists of rotating augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

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- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method
 for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as
 the material is brought to the surface. Sampling of such formations requires the use of split-barrel or
 thin-wall tube samplers advanced through the hollow core of the auger.
- No drilling fluids are required.
- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.
- The inside diameter of hollow stem augers used for well installation should be at least 4 inches greater than the well casing. Use of such large-diameter hollow-stem augers is more expensive than the use of small-diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.
- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.
- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet.

Hollow-stem auger drilling is the preferred method of drilling. Most alternative methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods, great care must be taken to ensure that the method does not interfere with the collection of a representative sample (which may be the prime objective of the borehole construction). With this in mind, the preferred order of choice of drilling method after hollow-stem augering (HSA) is:

- Drill-through casing drive
- Jet drilling
- Hand auger

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow-stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The guidelines established in SOP SA-1.3 shall also be followed. The hollow-stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation. However, when drilling below the water table, specially designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This drilling configuration method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled

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and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see SOP GH-2.8 for well development procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader (in communication with the Project Manager), when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations, it may be prudent to also grout borings which penetrate only the water table aquifer, since loose soil backfill in the boring may still provide a preferred pathway for surface liquids to reach the water table. Backfilling requirements may also be driven by state or local regulations.

5.2.2 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig (or an air-hammer) and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage); a continuous record is kept of the blows per foot in driving the casing (see SOP GH-1.5). The casing is normally advanced by a 300-pound hammer falling freely through a height of 30 increes. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations within which wash water is used and in which the casing is driven must be clearly recorded.

The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least 4 inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

- Split-barrel (split-spoon) sampling can be conducted while drilling.
- Well installation is easily accomplished.
- Drill rigs used are relatively small and mobile.
- The use of casing minimizes flow into the hole from upper water-bearing layers; therefore, multiple
 aquifers can be penetrated and sampled for rough field determinations of some water quality
 parameters.

Some of the disadvantages include:

- This method can only be used in unconsolidated formations.
- The method is slower than other methods (average drilling progress is 30 to 50 feet per day).
- Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.
- The cost per hour or per foot of drilling may be substantially higher than other drilling methods.

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• It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).

5.2.3 **Jet Drilling (Washing)**

Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2- to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.

Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch-diameter casing in shallow, unconsolidated sand formations, but this method has also been used to install 3- to 4-inch-diameter casings to a depth of 200 feet.

Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable. Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:

- Jetting is fast and inexpensive.
- Because of the small amount of equipment required, jetting can be accomplished in locations where
 access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a
 well point in the center of a lagoon at a fraction of the cost of using a drill rig.
- Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.

Disadvantages include the following:

- A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.
- Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.
- The diagneter of the casing is usually limited to 2 inches.
- Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the
 depth limitation is shallow (about 30 feet without jet percussion equipment).
- Large quantities of water are often needed.

5.2.4 Drilling with a Hand Auger

This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can also be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.

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Samples should be taken continuously unless otherwise specified by the project plan documents. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). These techniques are slow but effective where larger pieces of equipment do not have access, and where very shallow holes are desired (less than 15 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

5,2.5 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond-studded bit attached to the outer core barrel in a double-tube core barrel. The use of single-tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation of this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see Section 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the project plans. The most common core barrel diameters are listed in Attachment A.

Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole causing unsatisfactory coring, the hole should be reamed and a flush-joint casing installed to a point below the broken formation. The size of the flush-joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures
 may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Dfill rigs are relatively small and mobile.

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Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).
- Depth to water cannot accurately be determined if water is used for drilling.
- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods.

5.2.6 Drilling & Support Vehicles

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight, size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand carried to the borehole site. Drilling/sampling methods used with such equipment include:
 - Hand augers and lightweight motorized augers.
 - Retractable plug samplers--driven by hand (hammer).
 - Motorized cathead a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small-diameter cased borings. This rig is sometimes called a "monkey on a stick."
- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismounted tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.
- Small truck-mounted drilling equipment using a Jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs, the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.
- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has
 wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is
 also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel"
 rigs.

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- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the
 drill, derrick, winches, and pumps or compressors. The drill may be provided with a separate engine
 or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse
 circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground
 sites, the drilling equipment is sometimes mounted on vehicles having low pressure, very wide
 diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.
- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles include:
 - Barrel-float rigs a drill rig mounted on a timber platform buoyed by empty 55-gallon drums or similar flotation units.
 - Barge-mounted drill rigs.
 - Jack-up platforms drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.
- Drill ships for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.7 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8-inch or 7-7/8-inch bits will nominally drill 6-inch and 8-inch holes, respectively).

For obtaining split-barrel samples of a formation, samplers are commonly manufactured in sizes ranging from 2 inches to 3-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used and driven by a 140-pound (\pm 2-pound) hammer dropping 30 inches (\pm 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow-stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the project plan documents.

5.2.8 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site, the following must be considered:

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- The speed of the drilling method employed.
- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).
- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30 feet to 50 feet) boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
follow-stem augers	75'
Solid-stem augers	50'
Mud-Rotary Drilling	100' (cuttings samples)
Rotosonic Drilling	100'-160' (continuous core)
Reverse-Circulation Rotary	100' (cuttings samples)
Skid-Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
land Auger	Varies
Continuous Rock Coring	50'

5.3 Prevention of Cross-Contamination

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe (a method similar to the rock coring method described in Section 5.2.10, except that larger casing is used) or by using a driven-casing method (see Section 5.2.6 of this guideline) and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing (usually of 8-inch diameter) is installed followed by installation of the well casing (6-inch-diameter is common for 2-inch wells). This well casing is driven into the confining layer to ensure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end, is installed to the surface.

Clean sand is placed in the annulus around and to a point of about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

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5.4 Cleanout of Casing Prior to Sampling

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, the cleaning should never be accomplished with a strong, downward-directed jet which will disturb the underlying soil. When clean out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split-barrel (splitspoon) sampler with the ball check valve removed as the clean-out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split-spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hardcemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner, there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the clean out auger, a split-barrel sample can be taken to remove it; bailers and sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler
 may become filled with the cuttings. This limits the amount of sample from the underlying formation
 which can enter and be retained in the sampler, and also raises questions as to the validity of the
 sample.
- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.
- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.
- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

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To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the site geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string, then measuring the height of this reference point above the ground surface. The difference of these measurements is the depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole must be recleaned prior to attempting sampling.

5.5 <u>Materials of Construction</u>

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in SOP GH-2.8. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long-term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods and procedures for their use must be provided by the site geologist and approved by the Project Manager. The specific slurry composition and the concentration of suspected contaminants for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field by the judgment of the site geologist and noted in the site logbook, and only after approval by the Project Manager, a vegetable oil or silicone-based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

5.6 Subsurface Soil Samples

Subsurface soil samples are used to characterize subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

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Surface protocols for various soil sampling techniques are discussed in SOP SA-1.3. Continuous-core soil sampling and rock coring are discussed below. The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

The CME continuous sample tube system provides a method of sampling soil continuously during hollow-stem augering. The 5-foot sample barrel fits within the lead auger of a hollow-auger column. The sampling system can be used with a wide range of I.D. hollow-stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailings, etc. This method is particularly used when SPT samples are not required and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required. Rotosonic drilling methods also provide a continuous soil sample.

5.7 Rock Sampling (Coring) (ASTM D2113-83)

Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. Rock coring can, however, proceed for thousands of feet continuously, depending on the size of the drill rig, and yields better quality data than air-rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average output in a 10-hour day ranges from 40 to over 200 feet. Down hole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Figure 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross-contamination of aquifers.

Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).

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FIGURE 1
STANDARD SIZES OF CORE BARRELS AND CASING

Coring Bit Size	Nom	inal*	Set Size*	
	O.D.	I.D.	O.D.	I.D.
RWT	1 5/32	3/4	1.160	0.735
EWT	1 1/2	29/32	1.470	0.905
EX, EXL, EWG, EWM	1 1/2	13/16	1.470	0.845
AWT	1 7/8	1 9/32	1.875	1.281
AX, AXL, AWG, AWM	1 7/8	1 3/16	1.875	1.185
BWT	2 3/8	1 3/4	2.345	1.750
BX, BXL, BWG, BWM	2 3/8	1/5/8	2.345	1.655
NWT	3	2 5/16	2.965	2.313
NX, NXL, NWG, NWM	3	2 1/8	2.965	2.155
HWT	3 29/32	3 3/16	3.889	3.187
HWG	3 29/3/2	3	3.889	3.000
2 3/4 x 3 7/8	3/7/8	2 3/4	3.840	2.690
4 x 5 1/2	5 1/2	4	5.435	3.970
6 x 7 3/4	7 3/4	6	7.655	5.970
AX Wire line/_/	1 7/8	1	1.875	1.000
BX Wire line	2 3/8	1 7/16	2.345	1.437
NX Wire line/_/	3	1 15/16	2.965	1.937

^{*} All dimensions are in inches; to convert to millimeters, multiply by 25.4.

[✓] Wire line dimensions and designations may vary according to manufacturer.

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FIGURE 1 STANDARD SIZES OF CORE BARRELS AND CASING PAGE TWO

Size Des	ignations			sing pling					nate Core neter
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; rod couplings	Casing O.D., Inches	O.D., Inches	I.D., Inches	Casing bit O.D., Inches	Core barrel bit O.D., Inches*	Drill rod O.D., Inches	Normal, Inches	Thinwall, Inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094		0.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	0.845	0.905
AX	Α	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
ВХ	В	2.875	2.875	2.375	2.965 /	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4,625	3.890	3.500	3.000	3.187
RW	RW	1.437			1.485	1.160	1.094		0.735
EW	EW	1.812			1.875	1.470	1.375	0.845	0.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875	٦ţ	/g	2.965	2.345	2,125	1.655	1.750
NW	NW	3.500	Flush Joint	No Coupling	3.615	2.965	2.625	2.155	2.313
HW	HW	4.500	usr/	ਲੌ	4.625	3.890	3.500	3.000	3.187
PW		5.500	jīŽ	2	5.650				
SW		6.625			6.790		J		
UW		7.625			7.800	-7			
ZW		8.625			8.810				
	AX_\	/				1.875	1.750	1.000	
	BXL_y					2.345	2.250	1.437	
	NX _ _\					2.965	2.813	1.937	

^{*} All dimensions are in inches; to convert to millimeters, multiply by 25.4.

/ Wire line dimensions and designations may vary according to manufacturer.

NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES. (DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-D-2889

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5.7.1 Diamond Core Drilling

A penetration of typically less than 6 inches per 50 blows using a 140-lb. hammer dropping 30 inches with a 2-inch split-barrel sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.

When formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used:

- Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the
 hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when
 necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing
 and if cross-contamination of aquifers in the unconsolidated materials is unlikely, leveling may be
 omitted
- Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 m), remove the core barrel from the hole and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equipment is the most commonly used size.
- When soft materials are encountered that produce less than 50 percent recovery, stop the core
 drilling. If soil samples are desired, secure such samples in accordance with the procedures
 described in ASTM Method D 1586 (Split-barrel Sampling) or in Method D 1587 (Thin-Walled Tube
 Sampling); sample soils per SOP SA-1.3. Resume diamond core drilling when refusal materials are
 again encountered.
- Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among
 the most important items to be detected and described, take special care to obtain and record these
 features. If such broken zones or cavities prevent further advance of the boring, one of the following
 three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the
 next smaller size core barrel, as conditions warrant.
- In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.

5.7.2 Rock Sample Preparation and Documentation

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in SOP GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as designating the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Project Geologist. The core boxes shall be constructed to accommodate

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at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with binged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows.

The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box, and the bottom of the cored interval is in the lower right corner of the box. The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- Project name.
- Project number.
- Boring number.
- Run numbers.
- Footage (depths).
- Recovery.
- RQD (%).
- Box number and total number of boxes for that boring (Example: Box 5 of 7).

For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

6.0 REFERENCES

Acker Drill Co., 1958. Basic Procedures of Soil Sampling. Acker Drill Co., Scranton, Pennsylvania.

American Institute of Steel Construction, 1978. <u>Manual of Steel Construction</u>, 7th Edition. American Institute of Steel Construction, New York, New York.

American Society for Testing and Materials, 1987. <u>ASTM Standards D1587-83, D1586-84, and D1452-80</u>. ASTM Annual Book of Standards, ASTM, Philadelphia, Pennsylvania, Vol. 4.08.

American Society for Testing and Materials, 1989. <u>Standard Practice for Diamond Core Drilling for Site Investigation</u>. ASTM Method D2113-83 (reapproved 1987), Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

Barcelona, M. J., J. P. Gibb and R. A. Miller, 1983. <u>A Guide to the Selection of Material for Monitoring Well Construction and Ground Water Sampling</u>. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

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BOART Longyear Co., Sonic Drilling. Environmental Drilling Division, Andova, Minnesota.

Central Mine Equipment Company, Drilling Equipment, St. Louis, Missouri.

Dept. of the Navy, Naval Facilities Engineering Command, 1982. Soil Mechanics Design Manual 7.1.

Driscoll, Fletcher G., 1986. Groundwater and Wells, 2nd Edition. Johnson Division, St. Paul, Minnesota.

Procedure GH-1.5 - Borehole and Sample Logging.

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Crosby and J. Fryberger, 1981. <u>Manual of Ground-Water Sampling Procedures</u>. NWWA/EPA Series. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

U.S. Department of the Interior, 1974, <u>Earth Manual</u>, A Water Resources Technical Publication, 810 pages.

U.S. EPA, 1980. <u>Procedure Manual for Ground Water Monitoring at Solid Waste Disposal Facilities</u>. SW-611. Office of Solid Waste, U.S. EPA, Cincinnati, Ohio.

W. L. Acker III, 1974. <u>Basic Procedures for Soil Sampling and Core Drilling</u>. Acker Drill Co., Inc., Scranton, Pennsylvania.

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ATTACHMENT A

DRILLING EQUIPMENT SIZES

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Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Hollow-stem augers (Ref. 7)	6 1/4	5	2 1/4	
	6 3/4	5 3/4	2 3/4	****
	7 1/4	6 1/4	3 1/4	
	13 1/4	12	6	
Thin Wall Tube Samplers (Ref. 7)		2	1 7/8	
		2 1/2	2 3/8	
		3	2 7/8	
		3 1/2	3 3/8	
		4 1/2	4 3/8	
		5	4 3/4	-
Drill Rods (Ref. 7)	RW	1 3/32	23/32	13/32
	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	Α	1 5/8	1. 1/8	9/16
	В	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thickness (Inches)
Driven External Coupled Extra Strong Steel* Casing (Ref. 8)	2 1/2	2.875	2.323	0.276
	3	3.5	2.9	0.300
	3 1/2	4.0	3.364	0.318
	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

^{*} Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

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Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Flush Coupled Casing (Ref. 7)	RX	1 7/16	1 3/16	1 3/16
·	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref. 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref. 7)	EWM	1 1/2	7/8**	
	AWM	1 7/8	1 1/8**	
	BWM	2 3/8	1 5/8**	
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 x 3 7/8	3 7/8	2 11/16	
	4 x 5 1/2	5 1/2	3 15/16	
	6 x 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16**	
	BQ (wireline)	2 23/64	1 7/16**	
	NQ (wireline)	2 63/64	1 7/8	
	HQ (wireline)	3 25/32	2 1/2	

^{**} Because of the fragile nature of the core and the difficulty to identify rock details, use of small-diameter core (1 3/8") is not recommended.

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Applicability

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BOREHOLE AND SAMPLE LOGGING

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1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

<u>Site Geologist</u>. Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used on site, the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 Materials Needed

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute hydrochloric acid (HCI)
- Ruler (marked in tenths and hundredths of feet)
- Hand Lens

5.2 Classification of Soils

All data shall be written directly on the boring log (Figure 1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

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\1L						MAT	ERIAL DESCRIPTION				PID/	FID Re	ading	(ppm)
mple and pe or tQD	Depth (FL) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/FL) or Screened	Soil Density/ Consistency or Rock	Color			U S C S	Remarks	Sample	Sampler BZ	Borehole**	Driller BZ**
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	EIEI D INEN	More Than Half of	COARSE-GRAINE of Material is LARGE	D SOILS R Than No. 200 S		WIFIED SOIL CLASSIFICATION		More Than Half of	FINE-GRAINED SI Material is SMALLER
(Excludin	ng Panticles Larger Than 3	Inches and Basing Fractions on	Estimated Weights	SYMBOL			Excluding Particles Larger Than 3 Inches	and Beeing Fractions on Estimated ction Smaller than No. 40 Sieve Size DRATANCY (Reaction to	
GRAVELS (50%(+)>1/4'@	CLEAN GRAVELS (LC Fines)	w % Wide range in grain signariicie sizes.	e and substantial amounts of all	Intermediate GW	Well graded gravets, gravet-sand mixtures, little or no lines.	SILTS AND CLAYS Liquid Limit «50	Characteristics) None to Septit	Shaking) Quick to Slow	Plastic Limit) None
	GRAVELS WIFINE	sizes missing.	e or a range of sizes with some		Poorly graded gravels, gravel-sand mixtures, little or no fine Silty gravels, poorly graded gravel-sand-sit mixtures.	<u> </u>	Medium to High Slight to Medium	None to Very Slow	Medium
SANDS 50%(+)<1/4°@	(High % Fines) CLEAN SANDS (Low % Fines)	Plastic fines (for identif	fication procedures, see GL)	gc	Clayery gravels, poorly graded gravel-sand-clay mixtures. Well graded sand, gravely sands, ittle or no fines.	SILTS AND CLAYS Liquid Limit >50	Slight to Medium	Slow to None None	Sight to Medium
33.1(1)(11)		Predominantly one sizes massing.	e or a range of sizes with some		Poorly graded sands, gravely sands, Ittle or no lines.		Medium to High	None to Very Slow	Säghi to Medium
	SANDS W/FINES (High % Fines)	Plastic tines (for identif	sentification procedures, see MC lication procedures, see CL)	sc	Sity sands, poorly graded sand-sit motures. Clayery sands, poorly graded sand-clay mixtures. gravel-sand mixture with clay binder.	HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy	feel and frequently by florous textur	
DESIGNATION INT LOSS SIDE SIDE SIDE SIDE SIDE SIDE SIDE SI	STANDARD P	INSTRATION RESISTANCE- LOWISFOOT 0-4 5-10 11-30 31-40 Oner 50	HARDNESS (FROM	CORE SAMPLES	ROCK TERMS	CONSISTENCY Very Soft Soft Medium SET SUR Very Soft Hard	UNC COMPRESSIVE STR (FORSEQ, F1) Less than 0.5 0.55 to 1.0 1.5 to 2.0 2.5 to 4.0 More than 4.0	8L0V	NATION RESISTANCE
Doscriptive Terms		Screeniriver or Ki	nile Effects		Hammer Effects	Cescriptiv	a Terms A	bbreviation (V. Br.)	Specing 0.2"
Medium Soft Medium Hard Hard	Ca Ca	ally Gouged In be Gouged In be scratched		Crushee when presend Breaks (one blow); crum Breaks (one blow); sharp Breaks conchoidally (see	bly adges	Very Bolden Boten Blocky Blocky Measter		(BL) (M.)	3-10 1-3-
	SOIL Barrel Sample O Undisturbed Sample or Samples, Specify in Per	SAMPLES - TYPES			BOOK SAMP, ES - X-MI (Conventional Core (-2-18" O.D.) G-MC (Minchel) Core Z - Other Core Stam, Specify in Remarks		•	12/16	WATER LEVELS V Initial WOuse & Depth Statelizad WOuse & Ospon
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5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (Continued).

This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse-grained soils shall be divided into rock fragments, sand, or gravel. The terms sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as " $(1/4 \text{ inch}\Phi-1/2 \text{ inch}\Phi)$ " or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer-grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split-barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.3. Those designations are:

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Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140-pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, or SC (see Figure 1).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Figure 2.

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength), or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are shown in Figure 2.

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
Trace	0 - 10 percent
Some	11 - 30 percent
Adjective form of the soil type (e.g., "sandy")	31 - 50 percent

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FIGURE 2

CONSISTENCY FOR COHESIVE SOILS

Consistency	Standard Penetration Resistance (Blows per Foot)	Unconfined Compressive Strength (Tons/Sq. Foot by pocket penetration)	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented with difficulty by thumbnail

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Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Figure 3.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

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FIGURE 3
BEDDING THICKNESS CLASSIFICATION

Thickness (metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	<1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

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5.3 Classification of Rocks

Rocks are grouped into three main divisions: sedimentary, igneous and metamorphic. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone Made up of granular materials less than 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.
- Claystone Very fine-grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale A fissile very fine-grained rock. Fractures along bedding planes.
- Limestone Rock made up predominantly of calcite (CaCO₃). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal Rock consisting mainly of organic remains.
- Others Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. Conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

5.3.1 Rock Type

As described above, there are numerous types of sedimentary rocks. In most cases, a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Figure 4 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a hand lens, the rock is a siltstone. If the grains are not distinguishable with a hand lens, the rock is a claystone.

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FIGURE 4

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter	
Cobbles	> 64 mm	
Pebbles	4 - 64 mm	
Granules	2 - 4 mm	
Very Coarse Sand	1 - 2 mm	
Coarse Sand	0.5 - 1 mm	
Medium Sand	0.25 - 0.5 mm	
Fine Sand	0.125 - 0.25 mm	
Very Fine Sand	0.0625 - 0.125 mm	
Silt	0.0039 - 0.0625 mm	

After Wentworth, 1922

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5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock color charts shall not be used unless specified by the Project Manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification (see Figure 3) will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail.
 Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).
- Medium soft Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.
- Medium hard No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.
- Hard Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the works "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokenness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) Less than 2-inch spacing between fractures
- Broken (BR.) 2-inch to 1-foot spacing between fractures
- Blocky (BL.) 1- to 3-foot spacing between fractures
- Massive (M.) 3 to 10-foot spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

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Method of Calculating RQD (After Deere, 1964)

RQD $\% = r/l \times 100$

- r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.
- I = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- Slight Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified).
- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic).
- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

• Seam - Thin (12 inches or less), probably continuous layer.

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- Some Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."
- Few Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."
- Interbedded Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."
- Interlayered Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.
- Rhyolite A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.
- Granite A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.
- Diorite A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.
- Gabbro A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse-grained dark igneous rock.

The following are some basic names that are applied to metamorphic rocks:

- Slate A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite A fine- to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 Abbreviations

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

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С	_	Coarse	Lt -	Light	YI -	Yellow
Med	-	Medium	BR -	Broken	Or -	Orange
F	-	Fine	BL -	Blocky	SS -	Sandstone
٧	-	Very	М -	Massive	Sh -	Shale
SI	-	Slight	Br -	Brown	LS -	Limestone
Осс	-	Occasional	BI -	Black	Fgr -	Fine-grained
Tr	-	Trace				

5.5 Boring Logs and Documentation

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections shall be used to complete the logs. A sample boring log has been provided as Figure 5.

The field geologist/engineer shall use this example as a guide in completing each boring log. Each boring log shall be fully described by the geologist/engineer <u>as the boring is being drilled</u>. Every sheet contains space for 25 feet of log. Information regarding classification details is provided either on the back of the boring log or on a separate sheet, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology at 13.7 feet, shall be lined off at the proportional location between the 13- and 14-foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.
- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split-spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.
- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.
- The density of granular soils is obtained by adding the number of blows for the last two increments.
 Refer to Density of Granular Soils Chart on back of log sheet. For consistency of cohesive soils refer
 also to the back of log sheet Consistency of Cohesive Soils. Enter this information under the
 appropriate column. Refer to Section 5.2.3.

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FIGURE 5 COMPLETED BORING LOG (EXAMPLE)

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- Enter color of the material in the appropriate column.
- Describe material using the USCS. Limit this column for sample description only. The predominant material is described last. If the primary soil is silt but has fines (clay) use clayey silt. Limit soil descriptors to the following:

Trace: 0 - 10 percentSome: 11 - 30 percentAnd/Or: 31 - 50 percent

- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.
- Enter USCS symbol use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.
- The following information shall be entered under the "Remarks" column and shall include, but is not limited by, the following:
 - Moisture estimate moisture content using the following terms dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.
 - Angularity describe angularity of coarse grained particles using the terms angular, subangular, subrounded, or rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.
 - Particle shape flat, elongated, or flat and elongated.
 - Maximum particle size or dimension.
 - Water level observations.
 - Reaction with HCl none, weak, or strong.

Additional comments:

- Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.
- Indicate odor and Photoionization Detector (PID) or Flame Ionization Detector (FID) reading if applicable.
- Indicate any change in lithology by drawing a line through the lithology change column and indicate the depth. This will help when cross-sections are subsequently constructed.
- At the bottom of the page indicate type of rig, drilling method, hammer size and drop, and any other useful information (i.e., borehole size, casing set, changes in drilling method).
- Vertical lines shall be drawn (as shown in Figure 5) in columns 6 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

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- Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent, and core recovery under the appropriate columns.
- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.
- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.
- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.
- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.
- Enter brokenness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.
- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:
 - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
 - Indicate calcareous zones, description of any cavities or vugs.
 - Indicate any loss or gain of drill water.
 - Indicate drop of drill tools or change in color of drill water.
- Remarks at the bottom of Boring Log shall include:
 - Type and size of core obtained.
 - Depth casing was set.
 - Type of rig used.
- As a final check the boring log shall include the following:
 - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.
 - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on

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identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5-foot intervals, sieve the cuttings (if mud rotary drilling) to
 obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future
 reference, and label the jar or bag (i.e. hole number, depth, date, etc.). Cuttings shall be closely
 examined to determine general lithology.
- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.
- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.
- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.
- Record this and any other useful information onto the boring log as provided in Figure 1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split-barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 Review

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs.
- Checking for conformance to the guideline.
- Checking to see that all information is entered in their respective columns and spaces.

6.0 REFERENCES

Unified Soil Classification System (USCS).

ASTM D2488, 1985.

Earth Manual, U.S. Department of the Interior, 1974.

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.

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Applicability

Prepared

Subject

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Approved

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1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of monitoring wells. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be determined during the project planning phases of the investigation, and any required permits must be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

<u>Piezometer</u> - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

<u>Potentiometric Surface</u> - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

<u>Well Point (Drive Point)</u> - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

<u>Driller</u> - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

<u>Field Geologist</u> - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

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5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well or piezometer:

- Health and safety equipment (hard hats, safety glasses, etc.) as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installation tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives and intended use for each monitoring well must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- · Sampling or monitoring for trace contaminants.
- Determining aguifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow directions and potential well locations can be determined by an experienced hydrogeologist through the review of geologic data and the site terrain. In addition, data from production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary investigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the depths at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The well diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling requirements, drilling method and cost.

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The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (5 feet or less) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

Standard monitoring well diameters are 2, 4, 6, or 8 inches. Drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the sampling devices that can be used are limited.

In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Length to Obtain 1 Gallon Water (Feet)	
2	6.13	
4	1.53	
6	0.68	

If a well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

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Pumping tests for determining aquifer characteristics may require larger diameter wells (for installation of high capacity pumps); however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "Schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength". Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe may corrode and release metal ions or chemically react with organic constituents, but this is considered a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary, and the annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The site geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

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5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a medium-to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally (i.e., no artificial sand pack installed). In this case, the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets, extending to the surface. The grout effectively seals the remaining borehole annulus and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom upward, to prevent bridging, and to provide a better seal. In shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets/chips or sand. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is typically placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

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A protective casing which is level with the ground surface (flush-mounted) is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter, manhole-type protective collar is set into the wet cement around the well with the top set level with or slightly above the pavement. An appropriately-sized id is placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 <u>Monitoring Well Installation</u>

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to ensure proper placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is slowly poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur. Centralizers may be used at the geologist's discretion, one above and one below the screen, to assure enough annular space for sand pack placement.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack. Pellets should be added slowly and their fall monitored closely to ensure that bridging does not occur.

The cement-bentonite grout is then mixed and tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between aquifers. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for

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installation of the monitoring well as detailed for overburden monitoring wells. Sufficient time (determined by the field geologist), must be allowed for setting of the grout prior to drilling through the confined layer.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 –10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. If a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be removed when the final well installation is completed.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drep hammer, or a mechanical vibrator. The screen section is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be manually driven to depths exceeding 10 feet.

Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA-2.5.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only small-diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials.

5.4 Well Development Methods

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity, turbidity, and temperature taken during development may yield information (stabilized values) regarding whether sufficient development has been performed. The selection of the well development method shall be made by the field geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

5.4.1 Overpumping and Backwashing

Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to

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remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is aggressively moved up and down within the well to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

5.4.3 Compressed Air

Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus introducing air into the formation and reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping of the well is subsequently done using the air lift method.

5.4.4 High Velocity Jetting

In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 RECORDS

A critical part of monitoring well installation is recording of all significant details and events in the site logbook or field notebook. The geologist must record the exact depths of significant hydrogeological features, screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed, ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded, depending on whether the well is completed in overburden (single- or double-cased), as a cased well in bedrock, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have an idea of the quantity of material needed to fill the annular

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space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in or bridging of the backfill materials. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

7.0 REFERENCES

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Cosby, and J. Fryberger, 1981: <u>Manual of Groundwater Sampling Procedures.</u> R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. <u>A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling.</u> ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. <u>Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities.</u> Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989.

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ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

KELATIVE CO	MICALID	ILII I OF KI	GID AAFF	L CASING I	NAI EIZIAE (L PLOCEN I	
Potentially-Deteriorating Substance	Type of	ype of Casing Material					
	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100.	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/ High Solids Content	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

1Teflon®5Lo-Carbon Steel2Stainless Steel 3166Galvanized Steel3.Stainless Steel 3047Carbon Steel

4 PVC 1

Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

Potentially- Deteriorating Substance	Type of Casing Material								
: 	PVC Flexible	PP.	PE Conv.	PE Linear	РММ	Viton**	Silicone	Neoprene	Teflon**
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/ High Solids Content	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

1 Teflon® 5 PE Conventional
2 Polypropylene (PP) 6 Plexiglas/Lucite (PMM)
3. PVC Flexible/PE Linear 7 Silicone/Neoprene
4 Viton®

* Trademark of DuPont

Source: Barcelona et al., 1983

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ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength are not critical.
Weight	Relatively heavier.	Light-weight; floats in water.
Cost	Relatively expensive.	Relatively inexpensive.
Corrosivity	Deteriorates more rapidly in corrosive water.	Non-corrosive may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned if organics will be subsequently sampled.	Never use glue fittings pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized.	May sorb or release organic substances.

See also Attachment A.

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GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING

Approved

Prepared

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the process to be used for purging groundwater monitoring wells prior to sampling, for collecting groundwater samples, and for measuring groundwater quality parameters.

2.0 SCOPE

This document provides information on proper sampling equipment, onsite water quality testing, safety measures to ensure the safety of the field technician(s), and techniques for groundwater sampling. All personnel are encouraged to review the information contained herein to facilitate planning of the field sampling effort. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

<u>Conductivity</u> – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions and their total concentration, mobility, valence, and relative concentrations and on temperature. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 microSiemens per centimeter (mS/cm) at 14°C.

<u>Dissolved Oxygen (DO)</u> – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

<u>Groundwater Sample</u> – A quantity of water removed from the ground, usually via a monitoring well that may or may not be lined with a well casing.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode immersed in water, as referenced against a reference electrode. A reference electrode commonly used in the field is the silver/silver chloride electrode, which has a voltage offset of about 210 mV from the standard hydrogen electrode (SHE). To convert field ORP measurements to equivalent SHE values, approximately 210 mV must be added to the ORP values obtained using the silver/silver chloride electrode. The actual offset depends on the concentration of the potassium chloride (KCI) in the field reference electrode and the temperature. Offsets typically range from 199 (saturated KCI) to 205 (3.5 Molar KCI) to 222 mV (1 Molar KCI) at 25°C and are greater at lower temperatures.

<u>pH</u> - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

<u>pH Paper</u> - Indicator paper that turns different colors depending on the <u>pH of the solution</u> to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's <u>pH</u>.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

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<u>Salinity</u> – The measurement of dissolved salts in a given mass of <u>solution</u>. Note: most field meters determined salinity automatically from <u>conductivity</u> and <u>temperature</u>. The value will be displayed in either parts per thousand (ppt) or <u>percent</u> (e.g., 35 ppt equals 3.5 <u>percent</u>). The parts per thousand symbol $\binom{0}{00}$ is not the <u>same as the percent</u> symbol $\binom{0}{0}$.

<u>Turbidity</u> – Turbidity in water is caused by suspended matter such as clay, silt, and fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

<u>Project Manager</u> - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of groundwater samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager identifies sampling locations.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP). This includes but is not be limited to performing air quality monitoring during sampling, boring and excavation activities, and ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO or SSO designee may also be required to advise the FOL on other safety-related matters regarding sampling, such as mitigative measures to address potential hazards from hazardous objects or conditions.

<u>Project Geologist/Sampler</u> - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

<u>Project Hydrogeologist</u> – This individual is responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), equipment to be used, and providing detailed input in this regard to the project planning documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of site sampling personnel.

<u>Field Operations Leader (FOL)</u> – This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather)
 conditions.
- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

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5.0 HEALTH AND SAFETY

Specific safety and health precautions are identified throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard surfaces
- Slips, trips, and falls
- Cuts and lacerations
- Traffic hazards associated with sampling in parking areas and roadways and along highways.

Methods of avoiding these hazards are provided below.

Knee injuries – Many monitoring wells are installed as flush mounts. Personnel are required to kneel to open these wells and to take groundwater level measurements, etc. This could result in knee injuries from kneeling on stones/foreign objects and general damage due to stress on the joints. To combat this hazard:

- · Clear any foreign objects from the work area.
- Wear hard-sided knee pads.

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample wells. To minimize these hazards:

- Pre-survey well locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations - To prevent cuts and lacerations associated with groundwater sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to
 yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.
- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.
- Keep cutting surfaces clean and smooth.
- Secure items to be cut -- do not hold them against the opposing hand, a leg, or other body part.
- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.
- DO NOT throw broken glass or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

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Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities ASSUME THEY DO NOT SEE YOU OR MEMBERS
 OF YOUR FIELD CREW.
- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site
 personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind
 spot.
- **Provide a required free space of travel**. Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.
- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.
- Wear high-visibility vests to increase visual recognition by motorists.
- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver.
 Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.
- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

6.1 General

For information derived from a groundwater sample to be useful and accurate, the sample must be representative of the particular zone being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis to keep any changes in water quality parameters to a minimum.

CAUTION

A closed well may generate and accumulate gases due to biological degradation, evolution of volatile chemicals from groundwater into the air, or other chemical actions. These gases may also be artificially generated, such as in the case of air sparging or extraction wells, which may take several days to depressurize. See Section 6.6.2 for safety measures to be employed to protect sampling personnel.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air or nitrogen, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water sample due to external influences of the sampling technique(s). In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. Concentration gradients resulting from mixing and dispersion processes, layers of variable geologic permeability, and the presence of separate-phase product (e.g., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase

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contaminant concentrations in the collected sample compared to what is representative of the integrated water column as it naturally occurs at that point, resulting in the collection of a non-representative sample. To safeguard against collecting non-representative samples, the following approach shall be followed prior to sample acquisition:

CAUTION

Mechanical agitation of well water may cause off-gas generation of volatile contaminants, creating an inhalation exposure to the sampler(s). Where avoiding an inhalation exposure is not possible and mechanical agitation is possible, pump into closed-top containers to control potential air emissions.

- 1. If possible, position yourself (and the sampling equipment) upwind of the well head.
- 2. Purge the monitoring well to be sampled prior to obtaining any samples from it. Evacuation of three to five well volumes is recommended prior to sampling, unless low-flow purging and sampling methods are utilized as described in Section 6.7 (Consult the site-specific SAP for exact purging parameters). In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical as it is in a low-yielding well or in wells containing stagnant water.
- 3. For wells with low yields that are purged dry during sampling, evacuate the well and allow it to recover to 75 percent of full capacity prior to sample acquisition. If the recovery rate is fairly rapid (generally 300 mL per minute or greater), attempt to continue evacuation until the number of well volumes specified in the SAP is achieved. If this cannot be accomplished, allow recovery to 75 percent of capacity and begin sampling.

CAUTION

For moderate to high-yielding monitoring wells, an evacuation rate that does not cause excessive turbulence in the well should be selected. There is no absolute safeguard against contaminating the sample with stagnant water; hence, special techniques are required for purging to minimize the potential for sample contamination (see below).

- 4. For moderate to high-yielding monitoring wells, use one of the following purge techniques:
 - Place a submersible pump or the intake line of a surface pump or bailer just below the water surface when removing the stagnant water.
 - While purging and as the water level decreases, lower the pump or intake line as the water level drops in the well. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. After this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.
 - Unless otherwise directed, place the intake line of the sampling pump (or the submersible pump itself) near the center of the screened section, and pump approximately one casing volume of water from the well at a low purge rate equal to the well's recovery rate (low-flow sampling).

6.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform to the guidelines in SOP SA-6.1.

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The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

• <u>Sample packaging and shipping equipment</u> – Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler materials, ice, labels, and chain-of-custody documents.

Field tools and instrumentation

- Multi-parameter water quality meter with an in-line sample chamber capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity, and salinity, or individual meters (as applicable)
- pH Paper
- Camera and film (if appropriate)
- Appropriate keys (for locked wells)
- Water level indicator and/or oil-water interface probe if separate-phase product is expected

Pumps

- Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with drop lines and air-lift apparatus (compressor and tubing) where applicable.
- Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.
- Other sampling equipment Bailers, graduated cylinder, stopwatch, and inert line with tripod-pulley assembly (if necessary).
- Pails Plastic, graduated.
- Clean paper or cotton towels for cleaning equipment.
- Buckets with lids for collecting purge water.
- <u>Decontamination solutions</u> Deionized water, potable water, phosphate-free laboratory-grade detergent, and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

6.3 Calculations of Well Volume

To ensure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to know the volume of standing water in the well pipe (including well screen where applicable). This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form or equivalent electronic form(s) (see SOP SA-6.3):

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- 1. Obtain all available information on well construction (location, casing, screen, etc.).
- 2. Determine well or inner casing diameter.
- 3. Measure and record static water level (depth below ground level or top of casing reference point).
- 4. Determine depth of well by sounding using a clean, decontaminated, weighted tape measure or water level indicator.
- 5. Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
- 6. Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$

where: V = Static volume of well in gallons.

T = Linear feet of water in the well.

r = Inside radius of well casing in inches.

0.163 = Conversion factor (compensates for conversion

Conversion factor (compensates for conversion of casing radius

from inches to feet and cubic feet to gallons and pi.

7. Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

Measuring devices may become contaminated when gathering the above information if they are submerged in contaminated water. Decontamination of the tape or water level indicator must be conducted between measurements in different wells as follows:

- 1. Saturate a paper towel or clean cotton towel with deionized water.
- 2. As the measuring device is extracted, wipe the tape, changing the cleaning surface frequently.
- 3. After it is extracted, rinse the probe or tape using a spray bottle of deionized water over a bucket or similar collection container.

Based on the contaminant (oily, etc), it may be necessary to use a soap and water wash and rinse to remove contaminants. Isopropanol can be used on the probe/tape. However, it is recommended that the use of solvents on the tape be minimized because they could degrade the protective covering or possibly remove the scale designations. If isopropanol (or some other solvent) is used, assure that the manufacturer/supplier Material Safety Data Sheet (MSDS) is obtained, kept on site at a readily available location with other MSDSs, and reviewed by personnel prior to the first usage of the solvent. Also, add the substance to the site-specific Hazardous Chemical Inventory list (see Section 5 of the TtNUS Health and Safety Guidance Manual [HSGM], Hazard Communication Program and OSHA Standard 29 CFR 1910.1200).

6.4 Evacuation of Static Water - Purging

6.4.1 General

The amount to be purged from each well will be determined prior to sample collection. This amount will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of the aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately, the well can be pumped until parameters such as temperature, specific conductance, pH, and turbidity (as applicable)

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have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook or field notebook or on standardized data sheets or an equivalent electronic form(s).

6.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. All of these techniques involve equipment that is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of tubing equipped with a base plate and ball check-valve at the bottom. Bailers are comprised of stainless steel and plastic. They come in a variety of sizes, but the two most often used are 2 inches and 4 inches in diameter. An inert non-absorbent line such as polyethylene rope is used to lower and then raise the bailer to retrieve the sample. As the bailer is lowered into the water column, the ball is pushed up allowing the tube to be filled. When the bailer is pulled upward, the ball seats in the base plate preventing water from escaping.

Advantages of bailers include the following:

- There are few limitations on size and materials used.
- No external power source is needed.
- Bailers are inexpensive and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Splashing the bailer into the water or transfer of sample may cause aeration.
- The use of a bailer does not permit constant in-line monitoring of groundwater parameters.
- Use of bailers is physically demanding, especially in warm temperatures at personal protection equipment (PPE) levels above Level D.

Safety concerns using a bailer include the following:

- Muscle stress and strain, especially when using 4-inch bailers and when pulling from excessively deep wells.
- Entanglement, possible hand/finger injuries, and rope burns during a sudden release of the bailer back down the well.
- Direct contact with contaminants of concern and sample preservatives when discharging the bailer contents because there is not a high level of control during a direct pour, and splashing and indirect contact with contaminants/preservatives could occur.

Control measures for these hazards are provided in Section 6.6.2.

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Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low-volume pump that uses rollers to squeeze flexible tubing to create suction. This tubing can be dedicated to a well to prevent cross-contamination from well to well. Suction pumps are all portable, inexpensive, and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause loss of dissolved gases and volatile organics. Another limitation of these pumps is that they require a secondary energy source to drive them. Electrically driven pumps may require portable generators as energy sources. Air diaphragm pumps require air compressors and/or compressed gas cylinders to drive them. The advantage of the peristaltic pump is that it will operate from a portable battery source. Safety measures associated with these pumps are provided below.

Air-Lift and Gas-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force groundwater up a sampling tube. These pumps are also relatively inexpensive. Air- or gas-lift samplers are more suitable for well development than for sampling because the samples may be aerated as a result of pump action. Aeration can cause pH changes and subsequent trace metal precipitation or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. Operation principles vary, and displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include the following:

- They may have low delivery rates.
- Many models are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding of the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time consuming.

Compressed Gases

Safety concerns using compressed gases as an energy source in these pumps are numerous. The nitrogen gas or compressed air is provided in a compressed gas cylinder at a pressure of approximately 2,000 psi. If damaged, these cylinders can become dangerous projectiles. Additionally, a sudden release of a cylinder's contents can involve considerable force that could cause significant damage to the eyes and/or skin. Protective measures include the following:

- Always wear safety impact glasses when handling compressed gases.
- Always administer compressed gases through an appropriate pressure-reducing regulator.

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- When clearing the cylinder connection port, open the cylinder valve only enough to clear foreign debris. During this process, always position the cylinder valve so that it faces away from you and others.
- If the cylinder is designed to accept a valve protection cap always keep that protection cap in place, except the cylinder is connected for use.
- When using the cylinder, lay the cylinder on its side to avoid the potential of it falling and knocking the valve off (and becoming a missile).
- DO NOT use the compressed nitrogen or air to clean clothing or to spray off the skin. Small cuts in the
 protective layer of the skin may permit the gas to enter into the bloodstream, presenting the potential
 danger of an embolism.

See the project-specific HASP for additional direction concerning cylinder safe handling procedures pertaining to the safe handling, transportation, and storage of compressed gas cylinders.

Electrical Shock

Even in situations where portable batteries are used, the potential for electrical shock exists. This potential risk is increased in groundwater sampling activities because of the presence of groundwater near the batteries. This potential is also increased in (prohibited) situations where jury-rigging of electrical connections is performed. Other potential hazards occur when field samplers open the hood of a running car to access the battery as a power source. To control these hazards:

- If you are unfamiliar with electrical devices, do not experiment, get help, and get the proper equipment necessary to power your device.
- Use the proper portable power inverters for cigarette lighter connections to minimize the need to access the battery under the hood of your vehicle.
- Use of electrical generators may pose a number of hazards including noise, those associated with fueling, and indirect sample influence.

To minimize or eliminate electrical generator hazards:

- Inspect the generator before use. Ensure that the generator and any extension cords are rated for the intended operation and have a Ground Fault Circuit Interrupter (GFCI) in line to control potential electrical shock.
- Fuel the generator before purging and sampling to avoid loss of power during sampling.
- Fuel engines only when they are turned OFF and have cooled sufficiently to prevent a fire hazard.
- Place the generator and any fuel source at least 50 feet from the well to be sampled to avoid indirect influence to the sample from fuel vapors or emission gases.

Lifting Hazards

This hazard may be experienced when moving containers of purge water, equipment, cylinders, etc. To control these potential hazards:

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- Do not fill purge buckets to more than 80 percent of their capacity.
- Obtain a gas cylinder of sufficient size to complete the designated task but not too large to handle. Ksize cylinders weigh approximately 135 pounds and are difficult to handle. M-size cylinders weigh approximately 50 pounds and are easier to handle and move.
- When necessary, get help lifting and moving gas cylinders and other heavy objects. Minimize twisting and turning while lifting. If it is necessary to move these cylinders or generators over significant distance, use mechanical means (carts, etc.).
- Use proper lifting techniques as described in Section 4.4 of the HSGM.

6.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific conductance
- Temperature
- DO
- ORP
- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous waste site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, or colloidal material or other suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Because instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters used to measure field parameters require calibration on a daily basis. Refer to SOP SA-6.3 for an example equipment calibration log.

6.5.1 Measurement of pH

6.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken and recorded on the groundwater sample log sheet (Attachment B) or equivalent electronic form.

Two methods are given for pH measurement: the pH meter and pH indicator paper. Indicator paper is used when only an approximation of the pH is required or when pH meter readings need to be verified, and the pH meter is used when a more accurate measurement is needed. The response of a pH meter can be affected by high levels of colloidal or suspended solids, but the effect is generally of little significance. Consequently, specific methods to overcome this interference are not described. The

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response of pH paper is unaffected by solution interferences from color, turbidity, or colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

6.5.1.2 <u>Principles of Equipment Operation</u>

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific, or narrower range, pH range paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion activity (which is usually similar to concentration) across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

6.5.1.3 Equipment

The following equipment is to be used for obtaining pH measurements:

- A stand-alone portable pH meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Combination electrode with polymer body to fit the above meter. Alternately, a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- Buffer solutions, as specified by the manufacturer. If the buffer solutions are considered hazardous per 29 Code of Federal Regulations (CFR) 1910.1200 (Hazard Communication) or the volumes used are greater than consumer commodity levels, the SSO shall obtain MSDSs from the manufacturer for the specific buffer solutions (see Section 4 of the HSGM regarding the Hazard Communication Program)
- pH indicator paper to cover the pH range 2 through 12.
- Manufacturer's operation manual. All personnel must be familiar with the equipment operation to ensure that the integrity of samples is preserved and that the equipment is operated safely.

6.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure shall be used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

- 1. Inspect the instrument and batteries prior to initiation of the field effort.
- 2. Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.
- 3. If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).

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- 4. Calibrate the meter and electrode(s) on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on a water quality meter calibration log sheet (Attachment C) or equivalent electronic form.
- 5. Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. The failure of the measurements to stabilize must be clearly noted in the logbook or equivalent electronic form.
- 6. Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH standard unit. Also record the sample temperature (unless otherwise specified in the SAP, record temperatures to the nearest whole degree Fahrenheit or 0.5 degree Celsius).
- 7. Rinse the electrode(s) with deionized water.
- 8. Store the electrode(s) in an accordance with manufacturer's instructions when not in use.

Any visual observation of conditions that may interfere with pH measurement, such as oily materials or turbidity, shall be noted and avoided as much as possible.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is determined. To measure the pH with pH paper:

- 1. Collect a small portion of sample into a clean container.
- 2. Dip the pH paper into this small portion of sample.
- 3. Compare the color of the paper to the color chart that is provided with the pH paper and read the corresponding pH from the chart.
- 4. Record the pH value from the chart on the sampling log sheet.
- 5. Discard the used pH paper as trash.
- 6. Discard the small volume of sample that was used for the pH measurement with the other investigative derived waste.

6.5.2 Measurement of Specific Conductance

6.5.2.1 <u>General</u>

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

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Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample because temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect specific conductance. Most conductivity meters in use today display specific conductance in units of mS/cm, which is the conductivity normalized to a temperature of 25°C. These are the required units to be recorded on the groundwater sample log field form or equivalent electronic form.

6.5.2.2 <u>Principles of Equipment Operation</u>

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, and the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases, and salts such as hydrochloric acid, sodium carbonate, and sodium chloride, respectively, are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on the ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell, which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

6.5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- Stand-alone portable conductivity meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available that may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirements of the sampling program.

6.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are as follows (calibration shall be conducted according to manufacturer's instructions):

- 1. Check batteries and calibrate instrument before going into the field.
- 2. Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used for calibration.
- 3. Rinse the cell with one or more portions of the sample to be tested or with deionized water and shake excess water from the cell.

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- 4. Immerse the electrode in the sample and measure the conductivity.
- 5. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.
- 6. Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for troubleshooting assistance.

6.5.3 Measurement of Temperature

6.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in situ, or as quickly as possible in the field because collected water samples may rapidly equilibrate with the temperature of their surroundings.

6.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury-filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22). In addition, various meters such as specific conductance or DO meters that have temperature measurement capabilities may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

6.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample, use the following procedure:

- 1. Immerse the thermometer in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples that will undergo subsequent chemical analysis.
- 2. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

If a temperature meter or probe is used:

- 1. Calibrate the instrument according to manufacturer's recommendations prior to use.
- 2. Immerse the meter/probe in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the meter/probe shall not be inserted into samples that will undergo subsequent chemical analysis.
- 3. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

6.5.4 Measurement of Dissolved Oxygen

6.5.4.1 General

DO levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. In addition, the growth of many aquatic organisms and the rate of corrosivity are dependent on DO concentrations. Thus, analysis for DO is a key test in water pollution and waste

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treatment process control. If at all possible, DO measurements shall be taken in situ because concentrations may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of DO meters. Chemical methods of analysis (i.e., Winkler methods) are available but require more equipment and greater sample manipulation. Furthermore, DO meters using a membrane electrode are suitable for highly polluted waters because the probe is completely submersible and is not susceptible to interference caused by color, turbidity, or colloidal material or suspended matter.

6.5.4.2 <u>Principles of Equipment Operation</u>

DO probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH-) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode. This rate is proportional to the oxygen concentration in the water being measured.

Because the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, leaving the surface of the solution undisturbed.

DO probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases such as chlorine or with gases such as hydrogen sulfide that are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field logbook and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer. This compensation can counteract some of the temperature effects but not all of them.

6.5.4.3 Equipment

The following equipment is needed to measure DO concentrations:

- A stand-alone portable DO meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.
- · Manufacturer's operation manual.

6.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

DO probes differ as to instructions for use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure DO concentrations:

- 1. Check the DO meter batteries before going to the field.
- 2. Condition the probe in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.

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- 3. Calibrate the instrument in the field according to manufacturer's recommendations or in a freshly airsaturated water sample of known temperature.
- 4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.
- 5. Rinse the probe with deionized water.
- 6. Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells may be moved up and down to achieve the required mixing.
- 7. Record the DO content and temperature of the sample in a field logbook or on a sample log sheet or equivalent electronic form.
- 8. Rinse the probe with deionized water.
- 9. Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable because sample handling is not involved. This however may not always be practical.

Special care shall be taken during sample collection to avoid turbulence that can lead to increased oxygen solubilization and positive test interferences.

6.5.5 Measurement of Oxidation-Reduction Potential

6.5.5.1 <u>General</u>

ORP provides a measure of the tendency of organic or inorganic chemicals to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of reduced to oxidized species in the sample.

6.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as DO, may be correlated with ORP to provide knowledge of the quality of the solution, water, or wastewater.

6.5.5.3 Equipment

The following equipment is needed for measuring the ORP of a solution:

- A combination meter with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

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6.5.5.4 <u>Measurement Techniques for Oxidation-Reduction Potential</u>

The following procedure is used for measuring ORP:

- 1. Check the equipment using the manufacturer's recommended reference solution and check its batteries before going to the field.
- 2. Thoroughly rinse the electrode with deionized water.
- 3. If the probe does not respond properly to the recommended reference solution, verify the sensitivity of the electrodes by noting the change in millivolts when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease when the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note that the ORP drops sharply when the caustic is added (i.e., pH increases) thus indicating that the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions or the probe should be replaced.
- 4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.

6.5.6 Measurement of Salinity

6.5.6.1 <u>General</u>

Salinity is a unities property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Most field meters determine salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent).

6.5.6.2 <u>Principles of Equipment Operation</u>

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (such as are found in Standard Methods for the Examination of Water and Wastewater). Depending on the meter, the results are displayed in either ppt or percent. The salinity measurements are carried out in reference to the conductivity of standard seawater (corrected to salinity = 35 ppt).

6.5.6.3 Equipment

The following equipment is needed for salinity measurements:

- A multi-parameter water quality meter capable of measuring conductivity and temperature and converting them to salinity (e.g., Horiba U-22 or YSI 600 series).
- Calibration solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.6.4 Measurement Techniques for Salinity

The steps involved in taking salinity measurements are as follows (standardization shall be conducted according to manufacturer's instructions):

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- 1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.
- 2. Check batteries and calibrate the meter before going into the field.
- 3. Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.
- 4. Rinse the cell with the sample to be tested. This is typically accomplished as the probe is placed in line during the collection of the purge water up to the time of sample acquisition.
- 5. Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.
- Rinse the probes with deionized water.

6.5.7 Measurement of Turbidity

6.5.7.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter such as clay, silt, or other finely divided organic and inorganic matter and microscopic organisms including plankton.

It is important to obtain a turbidity reading immediately after taking a sample because irreversible changes in turbidity may occur if the sample is stored too long.

6.5.7.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method, which is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTUs) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

6.5.7.3 Equipment

The following equipment is needed for turbidity measurements:

- A turbidity meter (e.g., LaMotte 2020) that calibrates easily using test cells with standards of 0.0, 1.0, and 10 NTUs, or a combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution and sample tubes, as specified by the manufacturer.
- Manufacturer's operation manual.

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6.5.7.4 <u>Measurement Techniques for Turbidity</u>

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (I) are listed below (standardization shall be done according to manufacturer's instructions):

- 1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.
- 2. Check batteries and calibrate the instrument before going into the field.
- 3. Calibrate on a daily basis according to the manufacturer's instructions, and record all pertinent information on a turbidity meter calibration log sheet (Attachment C) or equivalent electronic form.
- 4. When using the YSI and/or Horiba U-22, rinse the electrode with one or more portions of the sample to be tested or with deionized water.
- 5. When using the Lamotte 2020, fill the light meter's glass test cell with approximately 5 mL of sample, screw on the cap, wipe off glass to remove all residue that could intercept the instrument's light beam, place the test cell in the light meter, and close the lid.
- 6. Immerse the electrode in the sample and measure the turbidity.
- 7. The reading must be taken immediately because suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
- 8. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
- 9. Rinse the electrode or test cell with deionized water.

6.6 Sampling

6.6.1 Sampling Plan

The sampling approach consisting of the following shall be developed as part of the project planning documents approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
- Intended number, sequence, volumes, and types of samples. If the relative degree of contamination between wells is insignificant, a sampling sequence that facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells. In situations where the well is not well-characterized and the nature or extent of airborne contamination is unknown, it is recommended that head space analysis using a photoionization detector (PID) or flame ionization detector (FID) is performed to rate the wells, sampling from least contaminated to most contaminated. Refer to the project-specific HASP for appropriate information and direction on air monitoring requirements.

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- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirements for split samples, access problems, location of keys, etc.
- The FOL shall ensure that the sampling method(s) to be employed is accurately represented in the HASP, indicating the types of sampling to be employed and the hazards. If the methods are not accurately represented, the FOL should rectify this with the HASP author.
- The FOL shall ensure that sampling teams understand the sampling approach that they are to follow.
 Where sampling teams are made up of personnel from multiple locations, personal sampling
 experiences may vary. Therefore the FOL shall review project-specific requirements, SOPs, and
 protocol to be followed. The FOL will conduct periodic surveys to ensure that these methods are
 being completed per his/her direction.

6.6.2 Sampling Methods as Related to Low-Flow Sampling

The collection of a groundwater sample consists of the following steps:

- 1. Ensure the safety of the sample location. Take a few minutes to evaluate the area for physical hazards (trip hazards, uneven ground, overhanging branches, etc.) and natural hazards (snakes, bees, spiders, etc.) that may exist in the area or that may have constructed nests in the well head. Snakes often like to sun themselves on concrete well pads. Follow provisions in the project-specific HASP and/or HSGM for addressing natural hazards.
- 2. As indicated earlier, some monitoring wells have the potential to contain pressurized headspace (e.g., through the generation of gases form contaminated groundwater, due to biological processes, degradation of contaminants, or simply based on location such as near a landfill or in areas that intersect lithological abnormalities) or through intentional artificial means such as those associated with air sparging systems. Injection or extraction wells may be artificially pressurized and may remain so for several days after the system has been turned off. This presents a hazard to people opening these wells. The Field Sampling Technician shall employ the following practices to minimize these hazards:
 - Wear safety glasses to protect the eyes. If site-specific observations and conditions indicate that the wells may be pressurized, wear a full-face shield over the safety impact eye protection.
 - DO NOT place your face or any other part of your body over the well when opening because this
 may place you in a strike zone.
 - Open the well cover at arms length, then step away and allow the well to off gas and stabilize.

Follow directions provided in the project-specific HASP, Work Plan and/or Sampling Plan pertaining to the use of volatile chemical detection equipment (PID or FID) within the breathing zone of the sampler during sampling to determine the need to retreat from the work area and/or for the use of respiratory protection (as specified in the HASP).

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- 3. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet or equivalent electronic form; then calculate the fluid volume in the well pipe (as previously described in this SOP). It is imperative that downhole equipment be adequately decontaminated between wells to prevent cross-contamination. Just as sampling occurs from the least contaminated to the most contaminated, it is also recommended that groundwater level measurements be taken in this manner.
- 4. Calculate volume of well water to be removed as described in Section 6.3.
- 5. Select the appropriate purging equipment (see Attachment A to this SOP) or as designated within your Work Plan/Sampling Plan. If an electric submersible pump with packer is chosen, go to Step 10.
- 6. Lower the purging equipment or intake into the well to a short distance below the water level or midscreen as indicated in project-specific documentation and begin water removal. Remember that some contaminants are "bottom dwellers," and in these cases, project-specific direction may specify placing the intake just above (1 to 2 feet) the well bottom. Secure the pump intake at the well and secure the effluent at the collection container and begin pumping. The pumping rate will be determined based on the decrease in the water level (see Section 6.7) or as directed in your project-specific documents or this SOP. Purge water is generally collected in a 5-gallon bucket or similar open- or closed-top container. To minimize the potential for spills and back injuries, do not fill 5-gallon buckets beyond approximately 80 percent of their capacity. Dispose of purge water was as indicated in the planning document(s). Where necessary, slow the pumping rate or lower the pump intake as required to maintain submergence.
- 7. Estimate the approximate rate of discharge frequently and record it on the Low Flow Purge Data Sheet (see Attachment D). Estimate flow rate by noting the amount of discharge in a bucket or graduated cylinder per unit time using a watch with a second hand or a stopwatch.
- 8. Observe the peristaltic pump tubing intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.
- 9. Purge a minimum of three to five casing volumes before sampling (or as directed by the site-specific SAP). In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recover to 75 percent of initial water level before sampling. Do not overfill purge containers because this increases the potential for spills and lifting injuries.
- 10. If sampling using a submersible pump, lower the pump intake to mid-screen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.
- 11. For pump and packer assemblies only: Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
- 12. If the recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this occurrence in the site logbook or equivalent electronic form. When this occurs, contact the analytical laboratory to alert them that a reduced sample volume(s) will be submitted for analysis.

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- 13. Fill sample containers and preserve and label them as described in SOP SA-6.1. Many sample bottles will contain preservative when they are shipped to the field. In those cases, do not add preservative.
- 14. Replace the well cap and lock it as appropriate. Make sure the well is readily identifiable as the source of the sample.
- 15. Process sample containers as described in SOP SA-6.1.
- 16. Decontaminate equipment as described in SOP SA-7.1.

6.7 <u>Low-Flow Purging and Sampling</u>

6.7.1 Scope and Application

Low-flow purging and sampling techniques may be required for groundwater sampling activities. The purpose of low-flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. This minimum-stress procedure emphasizes negligible water level drawdown and low pumping rates to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen length, or open interval, of 10 feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semivolatile organic compounds, pesticides, polychlorinated biphenyls [PCBs], metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This low-flow procedure is not designed for collection of non-aqueous phase liquid samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs).

This procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTUs and to achieve a water level drawdown of less than 0.3 foot during purging and sampling. If these goals cannot be achieved, sample collection can take place provided that the remaining criteria in this procedure are met.

6.7.2 Equipment

The following equipment is required (as applicable) for low-flow purging and sampling:

- Adjustable rate submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).
- Disposable clear plastic bottom-filling bailers to be used to check for and obtain samples of LNAPLs or DNAPLs.
- Tubing Teflon, Teflon-lined polyethylene, polyethylene, polyvinyl chloride (PVC), Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.
- Water level measuring device with 0.01-foot accuracy (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- · Interface probe.
- Flow measurement supplies.

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- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments pH, turbidity, specific conductance, and temperature.
 Use of a flow-through cell is recommended. Optional indicators ORP, salinity, and DO. A flow-through cell (also referred to as an in-line sample chamber) is required.
- Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s) and other forms (see Attachments B through D) or equivalent electronic form(s).
- Sample bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event (if available).
- Field Sampling Plan.
- PID or FID instrument for measuring volatile organic compounds (VOCs) per the HASP.

6.7.3 Purging and Sampling Procedure

- 1. Open the monitoring well as stated earlier and step away. Prepare sampling equipment while allowing 3 to 5 minutes to allow the water level to reach equilibrium. In situations where VOCs are the primary contaminants of concern, air monitoring of the samplers' breathing zone areas may be required by the HASP (typically with a PID or FID).
- 2 Measure the water level immediately prior to placing the pump in the well and record the water level on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well.
- 3. Lower the measuring device further into the well to collect the total depth measurement. Again wait 3 to 5 minutes to allow the well to equilibrate to the initial water level prior to placing the pump or pump intake in the well.
- 4. Record the total well depth on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well
- 5. Lower the pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible, keep the pump intake at least 2 feet above the bottom of the well to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is 3 feet or less of standing water in the well.
- 6. Start with the initial pump rate set at approximately 0.1 liter per minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust the pumping rates as necessary to prevent drawdown from exceeding 0.3 foot during purging. If no drawdown is noted, the pump rate may be increased (to

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a maximum of 0.4 liter per minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below the top of the well screen, purging shall cease or the well shall be pumped to dryness and then allowed to recover before purging continues. Well recovery to 75 percent is necessary prior to sampling. Slow-recovering wells should be identified and purged at the beginning of the workday to maximize field work efficiency. If possible, samples should be collected from these wells within the same workday and no later than 24 hours after the end of purging.

- 7. Measure the water level in the well every 5 to 10 minutes using the water level meter. Record the well water level on the Low Flow Purge Data Form (Attachment D) or equivalent electronic form.
- 8. Record on the Low Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, ORP, DO, and salinity or as specified by the approved site-specific planning document) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form or equivalent electronic form.
- 9. Estimate the flow rate by noting the amount of discharge in a graduated cylinder per unit time using a watch with a second hand. Remeasure the flow rate any time the pump rate is adjusted and periodically during purging. This will determine if a reduction in rate has occurred due to possible battery depletion.
- 10. During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections and tighten, repair, or replace them as necessary to achieve a tight connection.
- 11. Wait until stabilization is achieved, or a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits, then begin sampling:
 - pH ±0.2 standard units
 - Specific conductance ±10%
 - Temperature ±10%
 - Turbidity less than 10 NTUs
 - DO ±10%
- 12. If the above conditions have not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form or equivalent electronic form.

NOTE: VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

- 13. If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples:
 - Collect samples for non-VOC analyses first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample for VOCs, and record the new flow rate.

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- Reduce the diameter of the existing tubing until the water column fills the tubing either by adding a
 connector (Teflon or stainless steel) or clamp, which should reduce the flow rate by constricting
 the end of the tubing. Proceed with sample collection.
- Insert a narrow-diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, then collect the sample from the narrow diameter tubing.
- Prepare samples for shipping as per SOP SA-6.1.

7.0 REFERENCES

American Public Health Association, 1989. <u>Standard Methods for the Examination of Water and Wastewater</u>, 17th Edition, APHA, Washington, D.C.

Barcelona, M. J., J. P. Gibb and R. A. Miller, 1983. <u>A Guide to the Selection of Materials for Monitoring Well Construction and Groundwater Sampling.</u> ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

Johnson Division, UOP, Inc. 1975. <u>Ground Water and Wells, A Reference Book for the Water Well Industry.</u> Johnson Division, UOP, Inc., Saint Paul, Minnesota.

Nielsen, D. M. and G. L. Yeates, 1985. <u>A Comparison of Sampling Mechanisms Available for Small-Diameter Ground Water Monitoring Wells.</u> Ground Water Monitoring Review 5:83-98.

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Crosby and J. Fryberger, 1981. <u>Manual of Ground Water Sampling Procedures.</u> R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

- U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.
- U.S. EPA, 1980. <u>Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities.</u> Office of Solid Waste, United States Environmental Protection Agency, Washington, D.C.
- U.S. EPA, 1994. <u>Groundwater Sampling Procedure Low Flow Purge and Sampling (Draft Final).</u> U.S. Environmental Protection Agency, Region I.
- U.S. Geological Survey, 1984. <u>National Handbook of Recommended Methods for Water Data Acquisition</u>, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

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ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diame	ter Casing	Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet	Х	Х	Х	Х	Х			
	Water Level >25 feet	Х			Х				
2-Inch	Water level <25 feet	Х	Х	X	Х	Х	х		
	Water Level >25 feet	Х			Х		X		
4-Inch	Water level <25 feet	X	Х	X	Х	Х	х	х	х
	Water Level >25 feet	X			Х		х	X	х
6-Inch	Water level <25 feet				Х	Х		х	×
	Water Level >25 feet			·	Х			X	x
8-Inch	Water level <25 feet	· •			Х	Х		×	×
	Water Level >25 feet				Х		-	×	×

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ATTACHMENT A PURGING EQUIPMENT SELECTION PAGE 2

Manufacturer -	Model Name/Number	Principle of Operation	Maximum Outside Diameter/L ength (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	\$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015- 20 pump head	\$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	\$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	\$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	\$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	\$1,500- 3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	\$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	\$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	\$3,500	DC operated.
Leonard Mold and Die Works, Inc.		Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	\$1,400- 1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	\$125-160	Other materials and models available for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)		1.66/36	PVC	0-230	0-2,000 mL/min	\$300-400	Requires compressed gas; piezometric level indicator; other materials available.

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Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/L ength (Inches)	Construction Materials (w/Lines and Tubing)	(ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	\$1,200- 1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	\$2,600- 2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	\$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	\$1,300- 1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custo m	PVC, PP	No limit	250 mL/ft of bailer	\$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	\$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin [®] , Tygon [®]	0-125	0-4,000 mL/min	\$800- 1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

Other Abbreviations:

Polyethylene Polypropylene Polyvinyl chloride PE PP **PVC**

Not applicable AC Alternating current

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DC Direct current

SS Stainless steel PC Polycarbonate

Ethylene-propylene diene (synthetic rubber)

EPDM

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

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ATTACHMENT B

GROUNDWATER SAMPLE LOG SHEET

Project Site Name: Project No.:					Sampled	Location:	Page of _		
[] Domestic Well Data [x] Monitoring Well Data [] Other Well Type: [] QA Sample Type:					[] Hig	Sample: w Concenti th Concent	ration		
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EQUIPMENT CALIBRATION LOG

GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING

Revision

Effective Date 03/08

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Number

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EQUIPMENT CALIBRATION LOG

ATTACHMENT C

PROJECT NAME :					INSTRUMENT NAME/MODEL:				
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LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: PROJECT NUMBER:		WELL ID.: DATE:	
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Subject

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LOW FLOW PURGE DATA SHEET

ATTACHMENT D

Time	Water Level	Flow	pH	S. Cond.	Turb.	DO	Temp.	ORP	Salinity	Comments
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SURFACE WATER AND SEDIMENT SAMPLING

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes procedures and equipment commonly used for collecting environmental samples of surface water and aquatic sediment for either onsite examination and chemical testing or for offsite laboratory analysis.

2.0 SCOPE

The information presented in this document is applicable to all environmental sampling of surface waters (Section 5.3) and aquatic sediments (Section 5.5), except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions, and equipment different from those described herein.

3.0 GLOSSARY

Analyte - Chemical or radiochemical material whose concentration, activity, or mass is measured.

Composite Sample - A sample representing a physical average of grab samples.

<u>Environmental Sample</u> – A quantity of material collected in support of an environmental investigation that does not require special handling or transport considerations as detailed in SOP SA-6.1.

<u>Grab Sample</u> – A portion of material collected to represent material or conditions present at a single unit of space and time.

<u>Hazardous Waste Sample</u> – A sample containing (or suspected to contain) concentrations of contaminants that are high enough to require special handling and/or transport considerations per SOP SA-6.1.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

<u>Project Manager</u> - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of soil samples. The Project Manager also has the overall responsibility for seeing that all surface water and sediment sampling activities are properly conducted by appropriately trained personnel in accordance with applicable planning documents.

<u>Field Operations Leader</u> - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field

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technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface water and sediment samples. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

<u>Site Safety Officer (SSO)</u> - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP). This includes but is not be limited to performing air quality monitoring during sampling and boring and excavation activities, and ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO or SSO designee may also be required to advise the FOL on other safety-related matters regarding boring and sampling, such as mitigative measures to address potential hazards from hazardous objects or conditions.

<u>Project Geologist/Sampler</u> - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP and other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, , container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Precautions to preserve the health and safety of field personnel implementing this SOP are distributed throughout. The following general hazards may also exist during field activities, and the means of avoiding them must be used to preserve the health and safety of field personnel:

Bridge/Boat Sampling - Potential hazards associated with this activity include:

- Traffic one of the primary concerns as samplers move across a bridge because free space of travel is not often provided. Control measures should include:
 - When sampling from a bridge, if the samplers do not have at least 6 feet of free travel space or physical barriers separating them and the traffic patterns, the HASP will include a Traffic Control Plan.
 - The use of warning signs and high-visibility vests are required to warn oncoming traffic and to increase the visibility of sample personnel.
- Slips, trips, and falls from elevated surfaces are a primary concern. Fall protection shall be worn
 when or if samplers must lean over a rail to obtain sample material. A Fall Protection Competent
 Person (in accordance with Occupational safety and Health Administration [OSHA] fall protection
 standards) must be assigned to ensure that fall protection is appropriately and effectively employed
- Water hazards/drowning if someone enters the water from an elevated surface (such as a bridge or dock) and when sampling from a boat. To minimize this potential, personnel shall wear United states Goast Guard (USCG)-approved floatation devices, and the sampling crew must also have on hand a

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Type IV Throwable Personal Floatation Device with at least 90 feet of 3/8-inch rope. See Section 5.5.2 of this SOP.

• Within the HASP, provisions will also be provided concerning the requirement of a Safe Vessel Certification or the necessity to conduct a boat inspection prior to use. In addition, the HASP shall also specify requirements as to whether the operator must be certified as a commercial boat operator and whether members of the sampling team must have a state-specific safe boating certification.

Entering Water to Collect Samples – Several hazards are associated with this activity and can be mitigated as follows:

- Personnel must wear a USCG-approved Floatation Device (selected and identified in the HASP). The SSO shall ensure that the device selected is in acceptable condition and suitable for the individual using it. This includes consideration of the weight of the individual.
- Lifelines shall be employed from a point on the shore. This activity will always be conducted with a Buddy. See Section 6.5.2.
- Personnel shall carry a probe to monitor the bottom ahead of them for drop offs or other associated hazards.
- The person in the water shall exercise caution concerning the path traveled so that the lifeline does not become entangled in underwater obstructions such as logs, branches, stumps, etc., thereby restricting its effectiveness in extracting the person from the water.
- Personnel shall not enter waters on foot in situations where natural hazards including alligators, snakes, as well as sharks, gars, and other predators within inland waterways may exist.
- In all cases, working along and/or entering the water during high currents or flood conditions shall be prohibited.
- Personnel shall not enter bodies of water where known debris exists that could result in injuries from cuts and lacerations.

Sampling in marshes or tidal areas in some instances can be accomplished using an all-terrain vehicle (ATV). This is not the primary recommended approach because the vehicle may become disabled, or weather conditions or tidal changes could result in environmental damage as well as loss of the vehicle. The primary approach is recommended to be on foot where minimal disturbance would occur. The same precautions specified above with regard to sediment disturbance apply as well as the previously described safety concerns associated with natural hazards. The natural hazards include alligators, bees (nests in dead falls and tree trunks), snakes, etc. In addition, moving through and over this terrain is difficult and could result in muscle strain and slips, trips, and falls. Common sense dictates that the sampler selects the most open accessible route over moderate terrain. Move slowly and deliberately through challenging terrain to minimize falls. Mud boots or other supportive PPE should be considered and specified in the HASP to permit samplers to move over soft terrain with the least amount of effort. In these situations, it is also recommended, as the terrain allows, that supplies be loaded and transported in a sled over the soft ground.

Working in these areas, also recognize the following hazards and means of protection against them:

Insects are also a primary concern. These include mosquitoes, ticks, spiders, bees, ants, etc. The HASP will identify those particular to your area. Typical preventative measures include:

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- Use insect repellant. Approval of various repellants should be approved by the Project Chemist or Project Manager.
- Wearing light-colored clothing to control heat load due to excessive temperatures. In addition, it makes it easier to detect crawling insects on your clothing.
- Taping pants to boots to deny access. Again, this is recommended to control access to the skin by crawling insects. Consultation with the Project Health and Safety OfficerSSO/Health and Safety Manager is recommended under extreme heat loads because this will create conditions of heat stress.
- Performing a body check to remove insects. The quicker you remove ticks, the less likely they will become attached and transfer bacteria to your bloodstream. Have your Buddy check areas inaccessible to yourself. This includes areas such as the upper back and between shoulder blades where it is difficult for you to examine and even more difficult for you to remove.

Safety Reminder

If you are allergic to bee or ant stings, it is especially critical that you carry your doctor-recommended antidote with you in these remote sampling locations due to the extended time required to extract incapacitated individuals as well as the effort required to extract them. In these scenarios, instruct your Buddy in the proper administration of the antidote. In all cases, if you have received a sting, administer the antidote regardless of the immediate reaction, evacuate, and seek medical attention as necessary. The FOL and/or SSO will determine when and if you may return to the field based on the extent of the immune response and hazards or potential hazards identified in these locations. To the FOL and SSO, this is a serious decision you have to make as to whether to take someone vulnerable to these hazards into a remote location where you may not be able to carry them out. Consider it wisely.

Poisonous Plants – To minimize the potential of encountering poisonous plants in the field, at least one member of the field team needs to have basic knowledge of what these plants look like so that they can be recognized, pointed out to other field personnel, and avoided if at all possible. If the field team cannot avoid contact and must move through an area where these plants exist, the level of personal protective equipment (PPE) shall include Tyvek coveralls and enhanced decontamination procedures for the removal of oils from the tooling and/or equipment.

Temperature-Related Stress – Excessively cold temperatures may result in cold stress, especially when entering the water either intentionally or by accident. Provisions for combating this hazard should be maintained at the sample location during this activity. Excessively hot temperatures may result in heat stress especially in scenarios where equipment is packed through the marsh.

Because all of these activities are conducted outside, electrical storms are a significant concern. The following measures will be incorporated to minimize this hazard:

- Where possible, utilize commercial warning systems and weather alerts to detect storms moving into the area.
- If on or in the water, get out of the water. Move to vehicles or preferably into enclosed buildings with plumbing and wiring.
- Where warning systems are not available, follow the 30/30 Rule (if there are less than 30 seconds between thunder and lightning, go inside for at least 30 minutes after the last thunder).

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See Section 4.0 of the Health and Safety Guidance Manual (HSGM) for additional protective measures.

6.0 PROCEDURES

6.1 <u>Introduction</u>

Collecting a representative sample of surface water or sediment may be difficult because of water movement, stratification, or heterogeneous distribution of the targeted analytes. To collect representative samples, one must standardize sampling methods related to site selection, sampling frequency, sample collection, sampling devices, and sample handling, preservation, and identification. Regardless of quality control applied during laboratory analyses and subsequent scrutiny of analytical data packages, reported data are no better than the confidence that can be placed in the representativeness of the samples. Consult Appendix C for guidance on sampling that should be considered during project planning and that may be helpful to field personnel.

6.3.4 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type to be acquired. In general, the most representative samples are obtained from mid-channel at a stream depth of 0.5 foot in a well-mixed stream; however, project-specific planning documents will address site-specific sampling requirements including sample collection points and sampling equipment. The most frequently used samplers include the following:

- Peristaltic pump.
- Bailer
- Dip sampler
- Weighted bottle
- Hand pump
- Kemmerer
- Depth-integrating sampler

The dip sampler and weighted bottle sampler are used most often, and detailed discussions for these devices and the Kemmerer sampler are addressed subsequently in this section.

The criteria for selecting a sampler include:

- 1. Disposability and/or easy decontamination.
- 2. Inexpensive cost (if the item is to be disposed).
- 3. Ease of operation.
- 4. Non-reactive/non-contaminating properties Teflon-coated, glass, stainless-steel or polyvinyl chloride (PVC) sample chambers are preferred (in that order).

Measurements collected for each sample (grab or each aliquot collected for compositing) shall include but not be limited to:

- Specific conductance
- Temperature
- pH
- Dissolved oxygen

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Sample measurements shall be conducted as soon as the sample is acquired. Measurement techniques described in SOP SA-1.1 shall be followed. All pertinent data and results shall be recorded in a field notebook or on sample log sheets (see Attachment A) or an equivalent electronic form(s). These analyses may be selected to provide information on water mixing/stratification and potential contamination. Various types of water bodies have differing potentials for mixing and stratification.

In general, the following equipment if necessary for obtaining surface water samples:

- Required sampling equipment, which may include a remote sampling pole, weighted bottle sampler, Kemmerer sampler, or other device.
- Real-time air monitoring instrument (e.g., PID, FID) as directed in the project-specific planning document.
- Required PPE as directed in the project-specific planning document, which may include:
 - Nitrile surgeon's or latex gloves (layered as necessary).
 - Safety glasses.
 - Other items identified on the Safe Work Permit that may be required based on location-specific requirements (e.g., hearing protection, steel-toed work boots, hard hat). These provisions will be listed in the HASP or addressed by the FOL and/or SSO.

Safety Reminder

The use of latex products may elicit an allergic reaction in some people. Should this occur, remove the latex gloves, treat for an allergic reaction, and seek medical attention as necessary.

- Required paperwork (see SOP SA-6.3 and Attachments A and B to this SOP).
- Required decontamination equipment.
- Required sample containers.
- Sealable polyethylene bags (e.g., Ziploc® baggies).
- Heavy-duty cooler.
- lce.
- Paper towels and garbage bags.
- Chain-of-custody records and custody seals.

Dip Sampling

Specific procedures for collecting a dip or grab sample of surface water can vary based on site-specific conditions (e.g., conditions near the shore and how closely a sampler can safely get to the shore). The general procedure for collecting a sample using a pole or directly from the water body is as follows:

1. If using a remote sampling pole, securely attach the appropriate sample container to a pole of sufficient length to reach the water to be sampled. Samples for volatile analysis should be collected

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first. Use PPE as described in the HASP. When sample containers are provided pre-preserved or if the pole cannot accommodate a particular sample container, use a dedicated, clean, unpreserved bottle/container for sampling and transfer to an appropriately preserved container.

- 2. Remove the cap. Do not place the cap on the ground or elsewhere where it might become contaminated.
- 3. Carefully dip the container into the water just below the surface (or as directed by project-specific planning documents), and allow the bottle to fill. Sample bottles for volatile analysis must be filled with no headspace. Avoid contacting the bottom of the water body because this will disturb sediment that may interfere with the surface water sample.
- 4. Retrieve the container and carefully replace the cap securely. If using a container other than the sample bottle, pour the water from that container into the sample bottle and replace the cap securely.
- 5. Use a clean paper towel to clean and dry the outside of the container.
- 6. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.
- 7. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

Constituents measured in grab samples collected near the water surface are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration distributed throughout the water column and in the cross section. Therefore, as possible based on site conditions, the sampler may be required to augment dip samples with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

CAUTION

In areas prone to natural hazards such as alligators and snakes, etc., always use a buddy as a watch. Always have and use a lifeline or throwable device to extract persons who could potentially fall into the water. Be attentive to the signs, possible mounds indicating nests, and possible slides into the water. Remember that although snakes are typically encountered on the ground, it is not unheard of to see them on low-hanging branches. Be attentive to your surroundings because these may indicate that hazards are nearby.

Weighted Bottle Sampling

A grab sample can also be collected using a weighted holder that allows a bottle to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of glass or plastic bottle with a stopper, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The general procedure for sampling with this device is as follows:

 Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).

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- 2. When the desired depth is reached, pull out the stopper with a sharp jerk of the stopper line.
- 3. Allow the bottle to fill completely, as evidenced by the absence of air bubbles.
- 4. Raise the sampler and cap the bottle.
- 5. Use a paper towel to clean and dry the outside of the container. This bottle can be used as the sample container as long as the bettle is an approved container type.
- 6. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.
- 7 Proceed with the handling and processing of each sample container as described in SOP SA 6.2.

Kemmerer Sampler

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon-coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass, stainless steel or acrylic cylinder with rubber stoppers that leave the ends open while it is lowered in a vertical position (thus allowing free passage of water through the cylinder). A "messenger" is sent down the line when the sampler is at the designated depth to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles. The general procedure for sampling with this device is as follows:

- Gently lower the sampler to the desired depth.
- 2. When the desired depth is reached, send down the messenger to close the cylinder and then raise the sampler.
- 3. Open the sampler valve to fill each sample bottle (filling bottles for valatile analysis first).
- 4. Use a paper towel to clean and dry the outside of the container.
- 5. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.
- 6. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

6.3.5 Surface Water Sampling Techniques

Samples collected during site investigations may be grab samples or composite samples. The following general procedures apply to various types of surface water collection techniques:

- If a clean, pre-preserved sample container is not used, rinse the sample container least once with the
 water to be sampled before the sample is collected. This is not applicable when sample containers
 are provided pre-preserved because doing so will wash some or all of the preservative out of the
 bottle.
- For sampling moving water, collect the farthest downstream sample first, and continue sample collection in an upstream direction. In general, work from zones suspected of low contamination to zones of high contamination.
- Take care to avoid excessive agitation of the water because loss of volatile constituents could result.

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- When obtaining samples in 40 mL vials with septum-lined lids for volatile organics analysis, fill the container completely (with a meniscus) to exclude any air space in the top of the bottle and to be sure that the Teflon liner of the septum faces in after the vial is filled and capped. Turn the vial upside down and tap gently on your wrist to check for air bubbles. If air bubbles rise in the bottle, add additional sample volume to the container.
- Do not sample at the surface, unless sampling specifically for a known constituent that is immiscible and on top of the water. Instead, invert the sample container, lower it to the approximate depth, and hold it at about a 45-degree angle with the mouth of the bottle facing upstream.

6.4 Onsite Water Quality Testing

Onsite water quality testing shall be conducted as described in SOP SA-1.1.

6.5 Sediment Sampling

6.5.1 General

If composite surface water samples are collected, sediment samples are usually collected at the same locations as the associated surface water samples. If only one sediment sample is to be collected, the sampling location shall be approximately at the center of the water body, in a depositional area if possible based on sample location restraints (see below), unless the SAP states otherwise.

Generally, coarser-grained sediments are deposited near the headwaters of reservoirs. Bed sediments near the center of a water body will be composed of fine-grained materials that may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations of contaminants. The shape, flow pattern, bathymetry (i.e., depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (e.g., bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled, in general, and areas likely to show net erosion (i.e., high-velocity, turbulent areas) and suspension of fine solid materials shall be generally avoided. Follow instructions in the SAP, as applicable.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with respect to time, application of chemicals, and land use. Bottom sediments (especially fine-grained material) may act as a sink or reservoir for adsorbed heavy metals and organic contaminants (even if water column concentrations are less than detection limits). Therefore, it is important to minimize the loss of low-density "fines" during any sampling process.

Samples collected for volatile organic compound (VOC) analysis must be collected prior to any sample homogenization. Regardless of the method used for collection, the aliquot for VOC analysis must be collected directly from the sampling device (hand auger bucket, scoop, trowel), to the extent practical. If a device such as a dredge is used, the aliquot should be collected after the sample is placed in the mixing container prior to mixing.

In some cases, the sediment may be soft and not lend itself to collection by plunging EncoreTM or syringe samplers into the sample matrix. In these cases, it is appropriate to open the sampling device, (Encore barrel or syringe) prior to sample collection, and carefully place the sediment in the device, filling it fully with the required volume of sample.

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On active or former military sites, ordnance items may be encountered in some work areas. Care should be exercised when handling site media (such as if unloading a dredge as these materials may be scooped up). If suspected ordnance items are encountered, stop work immediately, move to shore and notify the Project Manager and Health and Safety Manager.

All relevant information pertaining to sediment sampling shall be documented as applicably described in SOP SA-6.3 and Attachment B or an equivalent electronic form.

6.5.2 Sampling Equipment and Techniques for Bottom Materials

A bottom-material sample may consist of a single scoop or core, or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using onshore or offshore techniques.

SAFETY REMINDER

The following health and safety provisions apply when working on/over/near water:

- At least two people are required to be present at the sampling location in situations where the water depth and/or movement deem itnecessary, each wearing a USCG-approved Personal Flotation Devices
- A minimum of three people are required if <u>any</u> of the following conditions are anticipated or observed:
 - Work in a waterway that is turbulent <u>or</u> swift that could sweep a sampler down stream should he or she fall in accidentally.
 - The underwater walking surface (e.g., stream/river bed) is suspected or observed to involve conditions that increase the potential for a worker to fall into the water. Examples include large/uneven rocks or boulders, dense mud or sediment that could entrap worker's feet, etc.
 - Waterway is tidal, and conditions such as those listed above could rapidly change.

The third person in the above condition must be equipped and prepared to render emergency support [e.g., lifeline, tethered Personal Flotation Device (Throwable Type IV, life saver), skiff, means to contact external emergency response support, etc.]

The following samplers may be used to collect sediment samples:

- Scoop sampler
- Dredge samplers
- Coring samplers

Each type of sampler is discussed below.

In general, the following equipment if necessary for obtaining sediment samples:

• Required sampling equipment, which may include a scoop sampler, dredge sampler, coring sampler, or stainless steel or pre-cleaned disposable trowel.

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- Stainless bowl or pre-cleaned disposable bowl to homogenize sample.
- Real-time air monitoring instrument (e.g., PID, FID) as directed in the project-specific planning document.
- Required PPE as directed in the project-specific planning document, which may include:
 - Nitrile surgeon's or latex gloves (layered as necessary).
 - Safety glasses.
 - Other items identified on the Safe Work Permit that may be required based on location-specific requirements (e.g., hearing protection, steel-toed work boots, hard hat). These provisions will be listed in the HASP or addressed by the FOL and/or SSO.
 - Required paperwork (see SOP SA-6.3 and Attachments A and B to this SOP).
 - Required decontamination equipment.
 - Required sample containers.
 - Sealable polyethylene bags (e.g., Ziploc® baggies).
 - Heavy-duty cooler.
 - ice.
 - Paper towels and garbage bags.
 - Chain-of-custody records and custody seals.

Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood, PVC, or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if the sampler can safely wade to the required location, the easiest and best way to collect a sediment sample is to use a scoop sampler. Scoop sampling also reduces the potential for cross-contamination. The general scoop sampling procedure is as follows:

- 1. Reach over or wade into the water body.
- 2. While facing upstream (into the current), scoop the sampler along the bottom in an upstream direction. Although it is very difficult not to disturb fine-grained materials at the sediment-water interface when using this method, try to keep disturbances to a minimum.

Dredge Samplers

Dredges are generally used to sample sediments that cannot easily be obtained using coring devices (e.g., coarse-grained or partially cemented materials) or when large quantities of sample are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a "messenger." Some dredges are heavy and may require use of a winch and crane assembly for sample retrieval. The three major types of dredges are Peterson, Eckman and Ponar.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The Peterson dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

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The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends, thus reducing the "shock wave." The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

The general procedure for using dredge samplers is as follows:

- 1. Gently lower the dredge to the desired depth.
- 2. When the desired depth is reached, send the messenger down to cable to close the cylinder and then carefully raise the sampler.
- 3. Open the sampler to retrieve the sediment.
- 4. Transfer the sediment to the bowl in which it will be homogenized. Fill the sample bottle(s) for volatile analysis *prior to* homogenization. Homogenize the remainder of the sediment collected.
- 5. Fill the containers for all analyses other and VOCs.
- 6. Use a paper towel to clean and dry the outside of each container.
- 7. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.
- 8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

SAFETY REMINDER

Safety concerns using these dredges include lifting hazards, pinches, and compressions (several pinch points exist within the jaws and levers). In all cases, handle the dredge by the rope to avoid capturing fingers/hands.

Coring Samplers

Coring samplers are used to sample vertical columns of sediment. Many types of coring devices have been developed depending on the depth of water from which the sample is to be obtained, the nature of the bottom material, and the length of core to be collected. They vary from hand-push tubes to electronic vibrational core tube drivers.

Coring devices are particularly useful in pollutant monitoring because turbulence created by descent through the water is minimal, thus the fines at the sediment-water interface are only minimally disturbed. The sample is withdrawn intact, permitting the removal of only those layers of interest.

In shallow, wadeable waters, the use of a core liner or tube manufactured of Teflon or plastic is recommended for the collection of sediment samples. Caution should be exercised not to disturb the bottom sediments when the sample is obtained by wading in shallow water. The general procedure to collecting a sediment sample with a core tube is as follows:

1. Push the tube into the substrate until 4 inches or less of the tube is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the tube while it is being pushed will facilitate greater penetration and decrease core compaction.

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- 2. Cop the top of the tube to provide suction and reduce the chance of losing the sample.
- 3. Slowly extract the tube so as not to lose sediment from the bottom of the tube. Cap the bottom of the tube before removing it from the water. This will also help to minimize loss of sample.
- 4. Transfer the sediment to the bowl in which it will be homogenized. Fill the sample bottle(s) for volatile analysis *prior to* homogenization. Homogenize the remainder of the sediment collected.
- 5. Fill the containers for all analyses other and VOCs.
- 6. Use a paper towel to clean and dry the outside of each container.
- 7. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.
- 8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

In deeper, non-wadeable water bodies, sediment cores may be collected from a bridge or boat using different coring devices such as Ogeechee Sand Pounders, gravity cores, and vibrating coring devices. All three devices utilize a core barrel with a core liner tube system. The core liners can be removed from the core barrel and replaced with a clean core liner after each sample. Before extracting the sediment from the coring tubes, the clear supernatant above the sediment-water interface in the core should be decanted from the tube. This is accomplished by turning the core tube to its side and gently pouring the liquid out until fine sediment particles appear in the waste liquid. Post-retrieval processing of samples is the same as above.

7.0 REFERENCES

American Public Health Association, 19.99 <u>Standard Methods for the Examination of Water and Wastewater</u>, 20th Edition, APHA, Washington, D.C.

Feltz, H. R., 1980. <u>Significance of Bottom Material Data in Evaluating Water Quality in Contaminants and Sediments.</u> Ann Arbor, Michigan, Ann Arbor Science Publishers, Inc., V. 1, p. 271-287.

Kittrell, F. W., 1969. <u>A Practical Guide to Water Quality Studies of Streams.</u> U.S. Federal Water Pollution Control Administration, Washington, D.C., 135 p.

- U.S. EPA, 1984. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-84-017.
- U.S. EPA, 2001. Environmental Investigations <u>Standard Operating Procedures and Quality Assurance Manual.</u> Water Surveillance Branch, USEPA Surveillance and Analytical Division, Athens, Georgia.
- U.S. Geological Survey, 1977. <u>National Handbook of Recommended Methods for Water-Data Acquisition.</u> Office of Water Data Coordination, USGS, Reston, Virginia.

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ATTACHMENT A

SURFACE WATER SAMPLE LOG SHEET

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ATTACHMENT B

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APPENDIX C

GUIDANCE ON SAMPLING DESIGN AND SAMPLE COLLECTION

C.1 <u>Defining the Sampling Program</u>

Many factors are considered in developing a sampling program for surface water and/or sediment, including study objectives, accessibility, site topography, physical characteristics of the water body (e.g., flow and mixing), point and diffuse sources of contamination, and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on vertical and lateral mixing within the body of water. For sediment, dispersion depends on bottom current or flow characteristics, sediment characteristics (e.g., density, size), and geochemical properties (that affect adsorption/desorption). The hydrogeologist developing the sampling plan must therefore know not only the mixing characteristics of streams and lakes but must also understand the role of fluvial-sediment transport, deposition, and chemical sorption.

C.1.1 Sampling Program Objectives

The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or within a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., contaminated runoff). The major pathways for surface water contamination (not including airborne deposition) are overland runoff, leachate influx to the water body, direct waste disposal (solid or liquid) into the water body, and groundwater flow influx from upgradient. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) that encompasses the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the locations of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc. shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. Such dispersion does not, however, always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation include: (1) moving the sampling location far enough downstream to allow for adequate mixing, or (2) collecting integrated samples in a cross section. Also, non-homogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to adsorb onto particulate matter. Nitrogen, phosphorus, and heavy metals may also be transported by particulates. Samples must be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

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C.1.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and consideration of site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes, reservoirs, or larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each contaminant would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed to ensure, as nearly as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of stream flow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Stream flow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gaging station is not conveniently located on a selected stream, the project hydrogeologist shall explore the possibility of obtaining stream flow data by direct or indirect methods. Remember these locations are also where you may encounter natural hazards as these are areas where they hunt. Always exercise extreme caution.

C.1.3 Frequency of Sampling

The sampling frequency and objectives of the sampling event will be defined by the project planning documents. For single-event site or area characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of a contaminant between the solid and aqueous phases, it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes (i.e., consisting of repetitive, continuing measurements to define variations and trends at a given location), water samples should be collected at a pre-established and constant interval as specified in the project plans (often monthly or quarterly and during droughts and floods). Samples of bottom material should generally be collected from fresh deposits at least yearly, and preferably seasonally, during both spring and fall.

The variability in available water quality data shall be evaluated before determining the number and collection frequency of samples required to maintain an effective monitoring program.

C.2 Surface Water Sample Collection

C.2.1 Streams, Rivers, Outfalls and Drainage Features

Methods for sampling streams, rivers, outfalls, and drainage features (ditches, culverts) at a single point vary from the simplest of hand-sampling procedures to the more sophisticated multi-point sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (see below).

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Samples from different depths or cross-sectional locations in the watercourse taken during the same sampling episode shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited. Generally, the number and type of samples to be taken depend on the river's width, depth, and discharge and on the suspended sediment the stream or river transports. The greater the number of individual points that are sampled, the more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling site can generally be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross section.

For larger streams, at least one vertical composite shall be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. The measurement of dissolved oxygen (DO), pH, temperature, conductivity, etc., shall be made on each aliquot of the vertical composite and on the composite itself. For rivers, several vertical composites shall be collected, as directed in the project planning documents.

C.2.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained. The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, measurement of DO, pH, temperature, etc. is to be conducted on each aliquot of the vertical composite and on the composite itself. In naturally formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites shall be composited to form a single sample if a sample representative of the water column is required. These vertical composites are often collected along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline that is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer that is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite consists of several vertical composites with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately represent water quality because it is likely that only poor mixing will occur. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements are now made in situ using sensors and automatic readout or recording devices. Single and multi-parameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, DO, some cations and anions, and light penetration.

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6.2.3 Estuaries

Estuarine areas are, by definition, zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Knowledge of the estuary type may be necessary to determine sampling locations. Estuaries are generally categorized into one of the following three types dependent on freshwater inflow and mixing properties:

- <u>Mixed Estuary</u> characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically, this type of estuary is shallow and is found in major freshwater sheet flow areas. Because this type of estuary is well mixed, sampling locations are not critical.
- <u>Salt Wedge Estuary</u> characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally back and forth with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.
- Oceanic Estuary characterized by salinities approaching full-strength oceanic waters. Seasonally, freshwater inflow is small, with the preponderance of the fresh-saline water mixing occurring near or at the shore line.

Sampling in estuarine areas is normally based on the tidal phase, with samples collected on successive slack tides (i.e., when the tide turns). Estuarine sampling programs shall include vertical salinity measurements at 1- to 5-foot increments, coupled with vertical DO and temperature profiles.

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SOIL SAMPLING

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used to collect surface, near-surface, and subsurface soil samples. Additionally, it describes the methods for sampling of test pits and trenches to determine subsurface soil and rock conditions and for recovery of small-volume or bulk samples from pits.

2.0 SCOPE

This document applies to the collection of surface, near-surface, and subsurface soil samples exposed through hand digging, hand augering, drilling, or machine excavating at hazardous substance sites for laboratory testing, onsite visual examination, and onsite testing.

3.0 GLOSSARY

<u>Composite Sample</u> - A composite sample is a combination of more than one grab sample from various locations and/or depths and times that is homogenized and treated as one sample. This type of sample is usually collected when determination of an average waste concentration for a specific area is required. Composite samples shall <u>not</u> be collected for volatile organics analysis.

Confined Space - As stipulated in 29 Code of Federal Regulations (CFR) 1910.146, a confined space means a space that: (1) is large enough and so configured that an employee can bodily enter and perform assigned work; (2) has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, pits, and excavations); and (3) is not designed for continuous employee occupancy. TtNUS considers all confined space as permit-required confined spaces.

Grab Sample - One sample collected at one location and at one specific time.

<u>Hand Auger</u> - A sampling device used to extract soil from the ground.

<u>Representativeness</u> – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

<u>Sample for Non-Volatile Analyses</u> - Includes all chemical parameters other than volatile organics (e.g., semivolatiles, pesticides/PCBs, metals, etc.) and those engineering parameters that do not require undisturbed soil for their analysis.

<u>Split-Barrel Sampler</u> - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split-barrel sampler is typically available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch-long samples, respectively. These split-barrel samplers commonly range in size from 2 to 3.5 inches OD. The larger sizes are commonly used when a larger volume of sample material is required (see Attachment B).

<u>Test Pit and Trench</u> - Open, shallow excavations, typically rectangular (if a test pit) or longitudinal (if a trench), excavated to determine shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by machine (e.g., backhoe, clamshell, trencher, excavator, or bulldozer).

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<u>Thin-Walled Tube Sampler</u> - A thin-walled metal tube (also called a Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outside diameter (OD) and from 18 to 54 inches in length.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

<u>Project Manager</u> - The Project Manager is responsible for determining the sampling objectives, selecting proposed sampling locations, and selecting field procedures used in the collection of soil samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager establishes the need for test pits or trenches and determines their approximate locations and dimensions.

<u>Site Safety Officer (SSO)</u> - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan. This will include (but not be limited to) performing air quality monitoring during sampling, boring, and excavation activities and to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO/designee may also be required to advise the FOL on other safety-related matters regarding boring, excavation, and sampling, such as mitigative measures to address potential hazards from unstable trench walls, puncturing of drums or other hazardous objects, etc.

Field Operations Leader (FOL) - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface, near-surface, and subsurface (hand and machine borings, test pits/trenches) soil samples. He/she is ultimately responsible for the sampling and backfilling of boreholes, test pits, and trenches and for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

<u>Project Geologist/Sampler</u> - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP and/or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, test pit logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

<u>Competent Person</u> - A Competent Person, as defined in 29 CFR 1929.650 of Subpart P - Excavations, means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

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5.0 HEALTH AND SAFETY

Health and safety precautions are identified for individual sample collection procedures throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- · Knee injuries from kneeling on hard or uneven surfaces
- Slips, trips, and falls
- Cuts and lacerations
- Traffic hazards associated with sampling in parking areas, along roadways and highways.

Methods of avoiding these hazards are provided below.

Knee injuries – If kneeling is required during soil sampling, this could result in knee injuries from stones/foreign objects and general damage due to stress on the joints. To minimize this hazard:

- · Clear any foreign objects from the work area.
- Wear hard-sided knee pads.
- Stretch ligaments, tendons and muscles before, during and after. Take breaks as frequently as necessary.
- Report pre-existing conditions to the SSO if you feel this activity will aggravate an existing condition.

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample locations. To minimize these hazards:

- Pre-survey sampling locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- · Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations - To prevent cuts and lacerations associated with soil sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.
- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.
- Keep cutting surfaces clean and smooth.
- Secure items to be cut do not hold them against the opposing hand, a leg, or other body part.
- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.

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 DO NOT throw broken sample jars or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities ASSUME THEY DO NOT SEE YOU OR MEMBERS
 OF YOUR FIELD CREW.
- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site
 personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind
 spot.
- Provide a required free space of travel. Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.
- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.
- Wear high-visibility vests to increase visual recognition by motorists.
- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.
- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

The following procedures address surface and subsurface sampling.

CAUTION

Each situation must be evaluated individually to determine the applicability and necessity for obtaining a utility clearance ticket/dig permit. Common sense dictates, prior to digging or boring with power equipment, no matter what the depth, or digging by hand in a manner that could damage unprotected underground utilities, that a dig permit is required. See SOP HS-1.0, Utility Locating and Excavation Clearance, for additional clarification. If you do not know or are unsure as to whether a ticket is necessary – **Get the Ticket**.

6.1 Overview

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they migrate to the water table, and can establish the amount of contamination absorbed or adsorbed on aquifer solids that have the potential of contributing to groundwater contamination.

Soil types can vary considerably on a hazardous waste site. These variations, along with vegetation, can affect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record

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be maintained during sampling operations, particularly noting sampling locations, depths, and such characteristics as grain size, color, and odor. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the associated microbiological community, thus further altering specific site conditions. Certain vegetation species can create degradation products that can alter contaminant concentrations in soil. This is why vegetation types and extent of degradation of this foliage must be recorded. To prevent degradation, samples must be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in approved glass containers, and be analyzed as soon as possible after collection. In addition, to the extent possible, vegetation should be removed from the sample.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table, will limit the depth from which samples can be collected and the method required to collect them. It is the intent of this document to present the most commonly employed soil sampling methods used at hazardous waste sites.

6.2 Soil Sample Collection

6.2.1 Procedure for Preserving and Collecting Soil Samples for Volatile Organic Compound Analysis

Samples collected using traditional methods such as collection in a jar with no preservation have been known to yield non-representative samples due to loss of volatile organic compounds (VOCs). To prevent such losses, preservation of samples with methanol or sodium bisulfate may be used to minimize volatilization and biodegradation. This preservation may be performed either in the field or laboratory, depending on the sampling methodology employed. Because of the large number of sampling methods and associated equipment required, careful coordination between field and laboratory personnel is needed.

Soil samples to be preserved by the laboratory are currently being collected using Method SW-846, 5035. For samples preserved in the field, laboratories are currently performing low-level analyses (sodium bisulfate preservation) and high- to medium-level analyses (methanol preservation) depending on the needs of the end user.

The following procedures outline the necessary steps for collecting soil samples to be preserved at the laboratory, and for collecting soil samples to be preserved in the field with methanol or sodium bisulfate.

6.2.1.1 Soil Samples to be Preserved at the Laboratory

Soil samples collected for volatile organic analysis that are to be preserved at the laboratory shall be obtained using a hermetically sealed sample vial such as an EnCore™ sampler. Each sample shall be obtained using a reusable sampling handle (T-handle) that can be provided with the EnCore™ sampler when requested and purchased. Collect the sample in the following manner for each EnCore™ sampler:

- 1. Scene Safety Evaluate the area where sampling will occur. Ensure that the area is safe from physical, chemical, and natural hazards. Clear or barricade those hazards that have been identified.
- 2. Wear the appropriate personal protective equipment (PPE). This will include, at a minimum, safety glasses and nitrile surgeon's gloves. If you must kneel on the ground or place equipment on the surface being sampled, cover the ground surface with plastic to minimize surface contamination of your equipment and clothing. Wear knee pads to protect your knees from kneeling on hard or uneven surfaces.

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- Load the Encore™ sampler into the T-handle with the plunger fully depressed.
- 4. Expose the area to be sampled using a hand trowel or similar device to remove surface debris.
- 5. Press the T-handle against the freshly exposed soil surface, forcing soil into the sampler. The plunger will be forced upward as the cavity fills with soil.
- 6. When the sampler is full, rotate the plunger and lock it into place. If the plunger does not lock, the sampler is not full. This method ensures there is no headspace. Soft soil may require several plunges or forcing soil against a hard surface such as a sample trowel to ensure that headspace is eliminated.
- 7. Use a paper towel to remove soil from the side of the sampler so a tight seal can be made between the sample cap and the rubber O-ring.
- 8. With soil slightly piled above the rim of the sampler, force the cap on until the catches hook the side of the sampler.
- 9. Remove any surface soil from the outside of the sampler and place in the foil bag provided with the sampler. Good work hygiene practices and diligent decontamination procedures prevents the spread of contamination even on the outside of the containers.
- 10. Label the bag with appropriate information in accordance with SOP SA-6.3.
- 11. Place the full sampler inside a lined cooler with ice and cool to 4°C ± 2 °C. Make sure any required trip blanks and temperature blanks are also in the cooler. Secure custody of the cooler in accordance with SOP SA-6.3.
- 12. Typically, collect three Encore™ samplers at each location. Consult the SAP or laboratory to determine the required number of Encore™ samplers to be collected.
- 13. The T-handle shall be decontaminated before moving to the next interval or location using a soap and water wash and rinse, and where applicable, the selected solvent as defined in the project planning documents.

Using this type of sampling device eliminates the need for field preservation and the shipping restrictions associated with preservatives. A complete set of instructions is included with each Encore™ sampler.

After the Encore management are collected, they should be placed on ice immediately and delivered to the laboratory within 48 hours (following the chain-of-custody and documentation procedures outlined in SOP SA-6.1). Samples must be preserved by the laboratory within 48 hours of sample collection.

6.2.1.2 / Soil Samples to be Preserved in the Field

Soil samples preserved in the field may be prepared for analyses using both the low-level (sodium bisuffate preservation) and high- to medium-level (methanol preservation) methods.

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Safety Reminder

When using chemicals in the field to preserve samples, the FOL and/or SSO must ensure that Materials Safety Data Sheets (MSDSs) have been provided with the chemicals to be used. They also must ensure that these chemicals have been added to the Chemical Inventory List contained within Section 5.0, Hazard Communication, of your Health and Safety Guidance Manual (HSGM). Lastly, but most importantly, the FOL and/or SSO must review the hazards with personnel using these chemicals and ensure that provisions are available for recommended PPE and emergency measures (e.g., eyewash, etc.).

Methanol Preservation (Nigh to Medium Level):

Bottles may be pre-spiked with methanol in the laboratory or prepared in the field. Soil samples to be preserved in the field with methanol shall utilize 40 to 60 mL glass vials with septum-lined lids. Each sample bottle shall be filled with 25 mL of demonstrated analyte-free purge-and-trap grade methanol. The preferred method for adding methanol to the sample bottle is by removing the lid and using a pipette or scaled syringe to add the methanol directly to the bottle.

CAUTION

NEVER attempt to pipette by mouth

In situations where personnel are required to spike the septum using a hypodermic needle, the following provisions for handling sharps must be in place:

- Training of personnel regarding methods for handling of sharps
- Hard-sided containers for the disposal of sharps
- Provisions for treatment in cases where persons have received a puncture wound

Soil shall be collected with the use of a decontaminated (or disposable), small-diameter coring device such as a disposable tube/plunger-type syringe with the tip cut off. The outside diameter of the coring device must be smaller than the inside diameter of the sample bottle neck.

A small electronic balance or manual scale will be necessary for measuring the volume of soil to be added to the methanol-preserved sample bottle. Calibration of the scale shall be performed prior to use and intermittently throughout the day according to the manufacturer's requirements.

The sample should be collected as follows:

- 1. Weigh the unused syringe and plunger to the nearest 0.01 gram.
- 2. Pull the plunger back and insert the syringe into the soil to be sampled.
- 3. Collect 8 to 12 grams of soil by pushing the syringe barrel into the soil.
- Weigh the sample and adjust until obtaining the required amount of sample.
- 5. Record the sample weight to the nearest 0.01 gram in the field logbook and/or on the sample log sheet.
- 6. Extrude the weighed soil sample into the methanol-preserved sample bottle taking care not to contact the sample container with the syringe.

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- If dirty, wipe soil particles from the threads of the bottle and cap. Cap the bottle tightly.
- 8. After capping the bottle, swirl the sample (do not shake) in the methanol and break up the soil such that all of the soil is covered with methanol.
- 9. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

Sodium Bisulfate Preservation (Low Level):

CAUTION

Care should be taken when adding the soil to the sodium bisulfate solution. A chemical reaction of soil containing carbonates (limestone) may cause the sample to effervesce or the vial to possibly explode. To avoid this hazard or hazards of this type, a small sample aliquot should be subjected to the sample preservative. If it effervesces in an open air environment, utilize an alternative method such as Encore™ or 2-ounce jar.

Bottles may be prepared in the laboratory or in the field with sodium bisulfate solution. Samples to be preserved in the field using the sodium bisulfate method are to be prepared and collected as follows:

- 1. Add 1 gram of sodium bisulfate to 5 mL of laboratory-grade deionized water in a 40 to 60 mL glass vial with septum-lined lid.
- 2. Collect the soil sample and record the sample weight to the nearest 0.01 gram in the field logbook or on the sample log sheet as described for methanol preservation
- 3. Add the weighed sample to the sample vial.
- 4. Collect duplicate samples using the methanol preservation method on a one-for-one sample basis because it is necessary for the laboratory to perform both low-level and medium-level analyses.
- 5. Place the samples on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

NOTE

If lower detection limits are necessary, an option to field preserving with sodium bisulfate may be to collect EnCore™ samplers at a given sample location. Consult the planning documents to determine whether this is required. If it is, collect samples in accordance with the Encore™ sampling procedure above and then send all samplers to the laboratory to perform the required preservation and analyses.

6.2.2 Procedure for Collecting Soil Samples for Non-Volatile Analyses

Samples collected for non-volatile analyses may be collected as either grab or composite samples as follows:

- 1. With a stainless steel trowel or other approved tool, transfer a portion of soil to be sampled to a stainless steel bowl or disposable inert plastic tray.
- 2. Remove roots, vegetation, sticks, and stones larger than the size of a green pea.

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- 3. Thoroughly mix the soil in the bowl or tray to obtain as uniform a texture and color as practicable. The soil type, moisture content, amount of vegetation, and other factors may affect the amount of time required to obtain a properly mixed sample. In some cases, it may be impossible to obtain a uniform sample appearance. Use the field logbook to describe any significant difficulties encountered in obtaining a uniform mixture.
- 4. Transfer the mixed soil to the appropriate sample containers and close the containers.
- 5. Label the sample containers in accordance with SOP SA-6.3.
- 6. Place the containers in a cooler of ice as soon after collection as possible.
- 7. Prepare the sample shipment and ship the samples in accordance with SOP SA-6.1.

NOTE

Cooling may not be required for some samples depending on the scheduled analyses.

Consult the planning documents if in doubt regarding correct sample preservation conditions. When in doubt – Cool to 4°C.

NOTE

Head space is permitted in soil sample containers for non-volatile analyses to allow for sample expansion.

6.2.3 Procedure for Collecting Undisturbed Soil Samples

NOTE

Use of thin-walled undisturbed tube samplers is restricted by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soil with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dennison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soil. Using these devices normally increases sampling costs, and therefore their use should be weighed against the need for acquiring an undisturbed sample. These devices are not discussed in this SOP because they are not commonly

When it is necessary to acquire undisturbed samples of soil for purposes of engineering parameter analysis (e.g., permeability), a thin-walled, seamless tube sampler (Shelby tube) shall be employed using the following collection procedure:

- 1. In preparation for sampling utilizing a drill rig, field personnel must complete the following activities:
 - Ensure that all subsurface drilling activities are preceded by a utility clearance for the area to be investigated. This includes activities described in SOP HS-1.0, Utility Location and Excavation Clearance, as well as any location-specific procedures that may apply.

REMEMBER

If you are digging near a marked utility (within the diameter of an underground utility that has been marked plus 18 inches), you must first locate the utility through vacuum extraction or hand digging to ensure that your activities will not damage the utility.

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- Complete an Equipment Inspection Checklist for the drill rig or direct-push technology (DPT) rig. This checklist will be provided in the HASP.
- Review the Safe Work Permit prior to conducting the activity.
- Review the activity to be conducted.
- 2. Remove all surface debris (e.g., vegetation, roots, twigs, etc.) from the specific sampling location and drill and/or clean out the borehole to the desired sampling depth. Be careful to minimize potential disturbance of the material to be sampled. In saturated material, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and to maintain the water level in the hole at or above groundwater level.

CAUTION

The use of bottom-discharge bits or jetting through an open-tube sampler to clean out the borehole shall not be allowed. Only the use of side-discharge bits is permitted.

- 4. Determine whether a stationary piston-type sampler is required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used.
- 5. Prior to inserting the tube sampler into the borehole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out the tube sampler during sample withdrawal. In addition, the check valve maintains a positive suction within the tube to help retain the sample.
- 6. A stainless steel tube sampler is typically used to minimize chemical reaction between the sample and the sampling tube.
- 7. With the sampling tube resting on the bottom of the hole and the water level in the boring at groundwater level or above, push the tube into the soil with a continuous and rapid motion, without impacting or twisting. If the soil is too hard to penetrate by pushing alone, careful hammering may be used by minimizing drop distance (tapping) of the hammer. Before pulling the tube, turn it at least one revolution to shear the sample off at the bottom. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.
- 8. Upon removal of the sampling tube from the hole, measure the length of sample in the tube and also the length penetrated.
- 9. Remove disturbed material in the upper end of the tube and measure the length of sample again.
- 10. After removing at least 1 inch of soil from the lower end, place enough packing material (clean inert material such as paper or cloth) tightly in each end of the Shelby tube and then pour melted wax into each end to make at least a ½-inch wax plug and then add more packing material to fill the voids at both ends.
- 11. Place plastic caps on the ends, tape the caps in place, and dip the ends in wax to prevent loss of soil.
- 12. Affix label(s) to the tube as required and record sample number, depth, penetration, and recovery length on the label.
- 13. Mark the "up" direction on the side and upper end of the tube with indelible ink.

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- 14. Complete a chain-of-custody form (see SOP SA-6.3) and other required forms (including Attachment A of this SOP).
- 15. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

CAUTION

To preserve sample integrity do not allow tubes to freeze, and store the samples vertically with the same orientation they had in the ground, (i.e., top of sample is up) in a cool place out of the sun at all times.

CAUTION

A primary concern in the preparation of the wax plugs is the potential for the heat source and melted wax to cause a fire and/or burns. Follow the directions below to prevent injury or fire.

Electrical Heating

Using hot plates to melt the wax is acceptable. In an outdoor setting, make sure a Ground Fault Circuit Interrupter (GFCI) is employed within the electrical circuit. If a portable generator is used, ensure that the generator is an adequate distance from the sampling operation (at least 50 feet). Ensure that the extension cord is rated for the intended load and for outdoor use and is free from recognizable damage. Ensure flammable preservatives are not employed or stored near the hot plate. Although a Hot Work Permit is not required, scene safety evaluation by site personnel of the above elements is. As always, if a fire potential exists, the provisions for extinguishing must be immediately accessible as well as any provisions for first aid measures.

Open Flame

If an open flame is used, the following provisions are necessary:

- Complete a Hot Work Permit and any local permit required for elevated temperature applications. The Hot Work Permit, provided in your HASP, will aid the FOL and/or the SSO in ensuring that fire protection provisions (extinguishers, fire watches, etc.) are in place as well as ensuring that local requirements have been addressed.
- Ensure that water is available to address any wax splashes or contact. If possible, immerse the contacted area. Where this is not possible, run water over the area and apply cold compresses. The need for medical attention or first aid shall be determined on site under the direction of the SSO.

6.3 Surface Soil Sampling

The simplest, most direct method of collecting surface soil samples for subsequent analysis is by use of a stainless steel shovel, hand auger, soil corer, or stainless steel or disposable plastic trowel.

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NOTE

Multiple depth intervals are used to describe surface soil. Sometimes surface soil is defined as soil from 0 to 2 inches below ground surface (bgs), and sometimes it is defined as soil from other depths such as 0 to 2 feet bgs. Ensure that the definition of surface soil depth is clear before collecting surface soil samples.

For the purposes of instruction, the terms "surface soil" and "near-surface soil" are used in this SOP as follows:

- Surface soil 0 to 6 inches bgs
- Near-surface soil 6 to 18 inches bgs

If these intervals are defined differently in the planning documents, substitute the appropriate depth ranges.

In general, the following equipment is necessary for obtaining surface soil samples:

- Stainless steel or pre-cleaned disposable trowel.
- Stainless steel hand auger, soil corer, or shovel.
- Real-time air monitoring instrument (e.g., PID, FID) as directed in project planning document.
- Required PPE.
 - Nitrile surgeon's or latex gloves may be used, layered as necessary.
 - Safety glasses
 - Other Items identified on the Safe Work Permit may be required based on location-specific requirements such as hearing protection, steel-toed work boots, and a hard hat when working near a drill rig. These provisions will be listed in the HASP or directed by the FOL and/or SSO.

Safety Reminder

The use of latex products may elicit an allergic reaction in some people. Should this occur, remove the latex gloves, treat for an allergic reaction, and seek medical attention as necessary.

- Required paperwork (see SOP SA-6.3 and Attachment A of this SOP)
- Required decontamination equipment
- Required sample container(s)
- Wooden stakes or pin flags
- Sealable polyethylene bags (e.g., Ziploc[®] baggies)
- Heavy duty cooler

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- lce
- Chain-of-custody records and custody seals

When acquiring surface soil samples, use the following procedure:

- 1. Place padding or use knee pads when kneeling near the sample location. If necessary, place plastic sheeting to provide a clean surface for sample equipment to avoid possible cross- contamination.
- 2. Carefully remove vegetation, roots, twigs, litter, etc. to expose an adequate soil surface area to accommodate sample volume requirements.
- 3. Using a precleaned syringe or EnCoreTM samplers, follow the procedure in Section 6.2.1 for collecting surface soil samples for volatile analysis. Surface soil samples for volatile organic analysis should be collected deeper than 6 inches bgs because shallower material has usually lost most of the volatiles through evaporation. Ensure that the appropriate surface soil depth is being analyzed in accordance with the planning document.
- 4. Using decontaminated sampling tools, thoroughly mix in place a sufficient amount of soil to fill the remaining sample containers. See Section 6.5 of this procedure for hand auger instruction, as needed.
- 5. Transfer the sample into those containers utilizing a stainless steel trowel.
- 6. Cap and securely tighten all sample containers.
- 7. Affix a sample label to each container. Be sure to fill out each label carefully and clearly, addressing all the categories described in SOP SA-6.3.
- 8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.
- 9. Site restoration Whenever removing sample materials, always restore the surface. It is our intent to leave the area better than we found it. Do NOT create trip hazards in areas when pedestrian traffic may exist.

6.4 Near-Surface Soil Sampling

Collection of samples from near the surface (depth of 6 to 18 inches) can be accomplished with tools such as shovels, hand auger, soil corers, and stainless steel or pre-cleaned disposable trowels and the equipment listed under Section 6.5 of this procedure.

To obtain near-surface soil samples, the following protocol shall be used:

- 1. With a clean shovel, make a series of vertical cuts in the soil to the depth required to form a square approximately 1 foot by 1 foot.
- 2. Lever out the formed plug and scrape the bottom of the freshly dug hole with a decontaminated stainless steel or pre-cleaned disposable trowel to remove any loose soil.
- 3. Follow steps 1 through 9 of Section 6.3.

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6.5 Subsurface Soil Sampling With a Hand Auger

A hand augering system generally consists of a variety of stainless steel bucket bits (approximately 6.5 inches long and 2, 2.75, 3.25, and 4 inches in diameter), series of extension rods (available in 2-, 3-, 4- and 5-inch lengths), and a T-handle connected to extension rods and to the auger bucket. A larger-diameter bucket bit is commonly used to bore a hole to the desired sampling depth and then it is withdrawn. The larger-diameter bit is then replaced with a smaller-diameter bit, lowered down the hole, and slowly turned into the soil to the completion depth (approximately 6 inches). The apparatus is then withdrawn and the soil sample collected.

The hand auger can be used in a wide variety of soil conditions. It can be used to sample soil either from the surface, or to depths in excess of 12 feet. However, the presence of subsurface rocks and landfill material and collapse of the borehole normally limit sampling depth.

To accomplish soil sampling using a hand augering system, the following equipment is required:

- Complete hand auger assembly (variety of bucket bit sizes)
- Stainless steel mixing bowls
- The equipment listed in Section 6.3
- Miscellaneous hand tools as required to assemble and disassemble the hand auger units

CAUTION

Potential hazards associated with hand augering include:

- Muscle strain and sprain due to over twisting and/or over compromising yourself.
- Equipment failure due to excessive stress on the T-handle or rods through twisting. Failure of any of these components will result in a sudden release and potential injury due to that failure.

As in all situations, any intrusive activities that could damage underground utilities shall be proceeded by a Dig/Excavation permit/ticket. Call the Utility Locating service in the area or your Project Health and Safety Officer for more information. When in doubt – **Get the Ticket!**

To obtain soil samples using a hand auger, use the following procedure:

- 1. Wearing designated PPE, attach a properly decontaminated bucket bit to a clean extension rod and attach the T-handle to the extension rod.
- 2. Clear the area to be sampled of any surface debris (vegetation, twigs, rocks, litter, etc.).
- 3. Twist the bucket into the ground while pushing vertically downward on the auger. The cutting shoes fill the bucket as it is advanced into the ground.
- 4. As the auger bucket fills with soil, periodically remove any unneeded soil.
- 5. Add rod extensions as necessary to extend the reach of the auger. Also, note (in a field notebook, boring log, and/or on a standardized data sheet) any changes in the color, texture or odor of the soil as a function of depth. The project-specific planning document (SAP, HASP, etc.) describe

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requirements for scanning the soil with a real-time air monitoring instrument (e.g., PID, FID, etc.) and recording the measurements.

- 6. After reaching the desired depth (e.g., the top of the interval to be sampled), slowly and carefully withdraw the apparatus from the borehole to prevent or minimize movement of soil from shallower intervals to the bottom of the hole.
- 7. Remove the soiled bucket bit from the rod extension and replace it with another properly decontaminated bucket bit. The bucket bit used for sampling is to be smaller in diameter than the bucket bit employed to initiate the borehole.
- 8. Carefully lower the apparatus down the borehole. Care must be taken to avoid scraping the borehole sides.
- 9. Slowly turn the apparatus until the bucket bit is advanced approximately 6 inches.
- 10. Discard the top of the core (approximately 1 inch), which represents any loose material collected by the bucket bit before penetrating the sample material.
- 11. Using a precleaned syringe or EnCoreTM samplers, follow the procedure in Section 6.2.1 for collecting a soil sample for volatile compound analysis directly from the bucket bit.
- 12. Utilizing a properly decontaminated stainless steel trowel or dedicated disposable trowel, remove the remaining sample material from the bucket bit and place into a properly decontaminated stainless steel mixing bowl.
- 13. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers. Refer to Section 6.2.2.
- 14. Follow steps 4 through 7 listed in Section 6.3.

6.5.1 Sampling Using Stainless Steel Soil Corers

A soil corer is a stainless steel tube equipped with a cutting shoe and sample window in the side. The soil corer is advanced into the soil by applying downward pressure (body weight). The soil is unloaded by then forcing a ram towards the cutting shoe, which results in the discharge of the soil core through a window in the sleeve.

Use, application, and sample protocol is the same as for hand augering provided above, but without necessarily rotating the corer while advancing it.

SAFETY REMINDER

Hand augering and soil corer sampling can be physically demanding based on the type of geology and subsurface encumbrances encountered. Soil coring has some added hazards such the corer collapsing under your weight. To reduce the potential for muscle strain and damage, the following measures will be incorporated:

- Stretch and limber your muscles before heavy exertion. This hazard becomes more predominant in the early morning hours (prior to muscles becoming limber) and later in the day (as a result of fatigue).
- Job rotation Share the duties so that repetitive actions do not result in fatigue and injury.

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- Increase break frequencies as needed, especially as ambient conditions of heat and/or cold stress may dictate.
- Do not force the hand tools or use cheater pipes or similar devices to bypass an obstruction. Move to another location near the sampling point. Exerting additional forces on the sampling devices can result in damage and/or failure that could potentially injure someone in the immediate vicinity.
- Do not over compromise yourself when applying force to the soil corer or hand auger.

 If there is a sudden release, it could result in a fall or muscle injury due to strain.

6.6 Subsurface Soil Sampling with a Split-Barrel Sampler

A split-barrel (split-spoon) sampler consists of a heavy carbon steel or stainless steel sampling tube that can be split into two equal halves to reveal the soil sample (see Attachment B). A drive head is attached to the upper end of the tube and serves as a point of attachment for the drill rod. A removable tapered nosepiece/drive shoe attaches to the lower end of the tube and facilitates cutting. A basket-like sample retainer can be fitted to the lower end of the split tube to hold loose, dry soil samples in the tube when the sampler is removed from the drill hole. This split-barrel sampler is made to be attached to a drill rod and forced into the ground by means of a 140-pound or larger casing driver.

Safety Reminder

It is intended through the Equipment Inspection for Drill Rigs form provided in the HASP that the hammer and hemp rope, where applicable, associated with this activity will be inspected (no physical damage is obvious), properly attached to the hammer (suitable knots or sufficient mechanical devices), and is in overall good condition.

Split-barrel samplers are used to collect soil samples from a wide variety of soil types and from depths greater than those attainable with other soil sampling equipment.

The following equipment is used for obtaining split-barrel samples:

- Drilling equipment (provided by subcontractor).
- Split-barrel samplers (2-inch OD, 1-3/8-inch ID, either 20 inches or 26 inches long); Larger OD samplers are available if a larger volume of sample is needed.
- Drive weight assembly, 140-pound weight, driving head, and guide permitting free fall of 30 inches.
- Stainless steel mixing bowls.
- Equipment listed in Section 6.3.

The following steps shall be followed to obtain split-barrel samples (Steps 1 through 4 are typically performed by the drilling subcontractor):

- 1. Attach the split-barrel sampler to the sampling rods.
- 2. Lower the sampler into the borehole inside the hollow stem auger bits.
- 3. Advance the split-barrel sampler by hammering the length (typically 18 or 24 inches) of the split-barrel sampler into the soil using 140-pound or larger hammer.
- When the desired depth is achieved, extract the drill rods and sampler from the augers and/or borehole.

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- 5. Detach the sampler from the drill rods.
- 6. Place the sampler securely in a vise so it can be opened using pipe wrenches.

CAUTION

Pipe wrenches are used to separate the split spoon into several components. The driller's helper should not apply excessive force through the use of cheater pipes or push or pull in the direction where, if the wrench slips, hands or fingers will be trapped against an immovable object.

- 7. Remove the drive head and nosepiece with the wrenches, and open the sampler to reveal the soil sample.
- 8. Immediately scan the sample core with a real-time air monitoring instrument (e.g., FID, PID, etc.) (as project-specific planning documents dictate). Carefully separate (or cut) the soil core, with a decontaminated stainless steel knife or trowel, at about 6-inch intervals while scanning the center of the core for elevated readings. Also scan stained soil, soil lenses, and anomalies (if present), and record readings.
- 9. If elevated vapor readings were observed, collect the sample scheduled for volatile analysis from the center of the core where elevated readings occurred. If no elevated readings where encountered, the sample material should be collected from the core's center (this area represents the least disturbed area with minimal atmospheric contact) (refer to Section 6.2.1).
- 10. Using the same trowel, remove remaining sample material from the split-barrel sampler (except for the small portion of disturbed soil usually found at the top of the core sample) and place the soil into a decontaminated stainless steel mixing bowl.
- 11. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers (refer to Section 6.2.2).
- 12. Follow steps 4 through 7 in Section 6.3.

6.7 <u>Subsurface Soil Sampling Using Direct-Push Technology</u>

Subsurface soil samples can be collected to depths of 40+ feet using DPT. DPT equipment, responsibilities, and procedures are described in SOP SA-2.5.

6.8 Excavation and Sampling of Test Pits and Trenches

6.8.1 Applicability

This subsection presents routine test pit or trench excavation techniques and specialized techniques that are applicable under certain conditions.

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CAUTION

During the excavation of trenches or pits at hazardous waste sites, several health and safety concerns arise from the method of excavation. No personnel shall enter any test pit or excavation over 4 feet deep except as a last resort, and then only under direct supervision of a Competent Person (as defined in 29 CFR 1929.650 of Subpart P -Excavations). Whenever possible, all required chemical and lithological samples should be collected using the excavator bucket or other remote sampling apparatus. If entrance is required, all test pits or excavations must be stabilized by bracing the pit sides using specifically designed wooden, steel, or aluminum support structures or through sloping and benching. Personnel entering the excavation may be exposed to text or explosive gases and oxygen-deficient environments; therefore, monitoring will be conducted by the Competent Person to determine if it is safe to enter. Any entry into a trench greater than 4 feet deep will constitute a Confined Space Entry and must be conducted in conformance with OSHA standard 29 CFR 1910.146. In all cases involving entry, substantial air monitoring, before entry, appropriate respiratory gear and protective clothing determination, and rescue provisions are mandatory. There must be at least three people present at the immediate site before entry by one of the field team members. This minimum number of people will increase based on the potential hazards or complexity of the work to be performed. The reader shall refer to OSHA regulations 29 CFR 1926.650, 29 CFR 1910.120, 29 CFR 1910.134, and 29 CFR 1910.146. Highhazard entries such as this will be supported by members of the Health Sciences Group professionally trained in these activities.

Excavations are generally not practical where a depth of more than about 15 to 20-feet is desired, and they are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pit, providing that pumped water can be adequately stored or disposed. If soil data at depths greater than 15-feet are required, the data are usually obtained through test borings instead of test pits.

In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.

6.8.2 Test Pit and Trengh Excavation

Test pits or trench excavations are constructed with the intent that they will provide an open view of subsurface lithology and/or disposal conditions that a boring will not provide. These procedures describe the methods for excavating and logging test pits and trenches installed to determine subsurface soil and rock conditions. Test pit operations shall be logged and documented (see Attachment C).

Test pits and trenches may be excavated by hand or power equipment to permit detailed descriptions of the nature and contamination of the in-situ materials. The size of the excavation will depend primarily on the following:

- The purpose and extent of the exploration
- The space required for efficient excavation
- The chemicals of concern
- The economics and efficiency of available equipment

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Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table provides guidelines for design consideration based on equipment efficiencies.

Equipment	Typical Widths, in Feet	
Trenching machine	0.25 to 1.0	
Backhoe/Track Hoe	2 to 6	

The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying.

The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, the following field conditions may necessitate revisions to the initial plans:

- Subsurface utilities
- Surface and subsurface encumbrances
- Vehicle and pedestrian traffic patterns
- Purpose for excavation (e.g., the excavation of potential ordnance items)

The final depth and construction method shall be collectively determined by the FOL and designated Competent Person. The actual layout of each test pit, temporary staging area, and spoils pile may further be predicated based on site conditions and wind direction at the time the test pit is excavated. Prior to excavation, the area may be surveyed by magnetometer or metal detector or other passive methods specified in SOP HS1.0, Utility Location and Excavation Clearance, to identify the presence of underground utilities or drums. Where possible, the excavator should be positioned upwind and preferably within an enclosed cab.

No personnel shall enter any test pit or excavation except as a last resort, and then only under direct supervision of a Competent Person. If entrance is required, OSHA requirements must be met (e.g., walls must be braced with wooder or steel braces, ladders must be placed for every 25 feet of lateral travel and extended 3 feet above ground surface). A temporary guard rail or vehicle stop must be placed along the surface of the hole before entry in situations where the excavation may be approached by traffic. Spoils will be stockpiled no closer than 2 feet from the sidewall of the excavation. The excavation equipment operator shall be careful not to undercut sidewalls and will, where necessary, bench back to increase stability. The top cover, when considered clean, will be placed separately from the subsurface materials to permit clean cover. It is emphasized that the project data needs should be structured such that required samples can be collected without requiring entrance into the excavation. For example, samples of leachate, groundwater, or sidewall soil can be collected with telescoping poles or similar equipment.

Dewatering and watering may be required to ensure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation stable. This is an important consideration for excavations in cohesionless material below the groundwater table and for excavations left open greater than a day. Liquids removed as a result of dewatering operations must be handled as potentially contaminated materials. Procedures for the collection and disposal of such materials should be discussed in the site-specific project plans.

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Where possible excavations and test pits shall be opened and closed within the same working day. Where this is not possible, the following engineering controls shall be put in place to control access:

- Trench covers/street plates
- Fences encompassing the entire excavation intended to control access
- Warning signs warning personnel of the hazards
- Amber flashing lights to demarcate boundaries of the excavation at night

Excavations left open will have emergency means to exit should someone accidentally enter.

6.8.3 Sampling in Test Pits and Trenches

6.8.3.1 General

Log test pits and trenches as they are excavated in accordance with the Test Pit Log presented in Attachment C. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records also include safety and sample screening information.

Entry of test pits by personnel is extremely dangerous, shall be avoided unless absolutely necessary, and can occur only after all applicable health and safety and OSHA requirements have been met as stated above. These provisions will be reiterated as appropriate in the project-specific HASP.

The final depth and type of samples obtained from each test pit will be determined at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may also be collected.

In some cases, samples of soil may be extracted from the test pit for reasons other than waste sampling and chemical analysis, for instance, to obtain geotechnical information. Such information includes soil types, stratigraphy, strength, etc., and could therefore entall the collection of disturbed (grab or bulk) or relatively undisturbed (hand-carved or pushed/driven) samples that can be tested for geotechnical properties. The purposes of such explorations are very similar to those of shallow exploratory or test borings, but often test pits offer a faster, more cost-effective method of sampling than installing borings.

6.8.3.2 <u>Sampling Equipment</u>

The following equipment is needed for obtaining samples for chemical or geotechnical analysis from test pits and trenches:

- Backhoe or other excavating machinery.
- Shovels, picks, hand augers, and stainless steel trowels/disposable trowels.
- Sample container bucket with locking lid for large samples; appropriate bottle wave for chemical or geotechnical analysis samples.
- Polyethylene bags for enclosing sample containers; buckets.
- Remote sampler consisting of 10-foot sections of steel conduit (1-inch-diameter), hose clamps, and right angle adapter for conduit (see Attachment D).

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6.8.3.3 Sampling Methods

The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 6.8.3.4.

- Excavate the trench or pit in several 0.5- to 1.0-foot depth increments. Where soil types support the use of a sand bar cutting plate, use of this device is recommended to avoid potentially snagging utilities with the excavator teeth. It is recommended that soil probes or similar devices be employed where buried items or utilities may be encountered. This permits the trench floor to be probed prior to the next cut.
- After each increment.
 - the operator shall wait while the sampler inspects the test pit from grade level
 - the sampler shall probe the next interval where this is considered necessary. Practical depth increments for lithological evaluations may range from 2 to 4 feet i or where lithological changes are noted.
- The backhoe operator, who will have the best view of the test pit, shall immediately cease digging if:
 - Any fluid phase, including groundwater seepage, is encountered in the test pit
 - Any drums, other potential waste containers, obstructions, or utility lines are encountered
 - Distinct changes of material being excavated are encountered

This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol. Depending on the conditions encountered, it may be required to excavate more slowly and carefully with the backhoe.

For obtaining test pit samples from grade level, the following procedure shall be followed:

- Use the backhoe to remove loose material from the excavation walls and floor to the greatest extent possible.
- Secure the walls of the pit, if necessary. (There is seldom any need to enter a pit or trench that would justify the expense of shoring the walls. All observations and samples should be taken from the ground surface.)
- Samples of the test pit material are to be obtained either directly from the backhoe bucket or from the material after it has been deposited on the ground, as follows:
 - a. The sampler or FOL shall direct the backhoe operator to remove material from the selected depth or location within the test pit/trench.
 - b. The backhoe operator shall bring the bucket over to a designated location on the sidewall a sufficient distance from the pit (at least 5 feet) to allow the sampler to work around the bucket.
 - After the bucket has been set on the ground, the backhoe operator shall either disengage the controls or shut the machine down.
 - d. When signaled by the operator that it is safe to do, the sampler will approach the bucket.

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- e. The soil shall be monitored with a photoionization or flame ionization detector (PID or FID) as directed in the project -specific planning documents.
- f. The sampler shall collect the sample from the center of the bucket or pile in accordance with surface soil sampling procedures of Section 6.3 or 6.4, as applicable. Collecting samples from the center of a pile or bucket eliminates cross-contamination from the bucket or other depth intervals.
- If a composite sample is desired, several depths or locations within the pit/trench will be selected, and the bucket will be filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample container shall be filled from materials that have been transferred into a mixing bucket and homogenized. Note that homogenization/compositing is not applicable for samples to be subjected to volatile organic analysis.

CAUTION

Care must be exercised when using the remote sampler described in the next step because of potential instability of trench walls. In situations where someone must move closer than 2 feet to the excavation edge, a board or platform should be used to displace the sampler's weight to minimize the chance of collapse of the excavation edge. Fall protection should also be employed when working near the edges or trenches greater than 6 feet deep. An immediate means to extract people who have fallen into the trench will be immediately available. These means may include ladders or rope anchor points.

- Using the remote sampler shown in Attachment D, samples can be taken at the desired depth from the sidewall or bottom of the pit as follows:
 - a. Scrape the face of the pit/trench using a long-handled shovel or hoe to remove the smeared zone that has contacted the backhoe bycket.
 - b. Collect the sample directly into the sample jar, by scraping with the jar edge, eliminating the need for sample handling equipment and minimizing the likelihood of cross-contamination.
 - c. Cap the sample jar, remove it from the remote sampler assembly, and package the sample for shipment in accordance with SOP SA-6.3.
- Complete documentation as described in SOP SA-6.3 and Attachment C of this SOP.

6.8.3.4 <u>In-Pit Sampling</u>

Under rare conditions, personnel may be required to enter the test pit/trench. This is necessary only when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g. excessive mixing of soil or wastes within the test pit/trench) or when samples from relatively small discrete zones within the test pit are required. This approach may also be necessary to sample any seepage occurring at discrete levels or zones in the test pit that are not accessible with remote samplers.

In general, personnel shall sample and log pits and trenches from the ground surface, except as provided for by the following criteria:

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- There are no practical alternative means of obtaining such data.
- The SSO and Competent Person determine that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of oxygen concentration, flammable gases, and toxic compounds, in that order). Action levels will be provided in project-specific planning documents.
- A company-designated Competent Person determines that the pit/trench is stable trough soil
 classification evaluation/inspections or is made stable (by cutting/grading the sidewalls or using
 shoring) prior to entrance of any personnel. OSHA requirements shall be strictly observed.

If these conditions are satisfied, only one person may enter the pit/trench. On potentially hazardous waste sites, this individual shall be dressed in selected PPE as required by the conditions in the pit. He/she shall be affixed to a harness and lifeline and continuously monitored while in the pit.

A second and possible third individual shall be fully dressed in protective clothing including a self-contained breathing device and on standby during all pit entry operations to support self rescue or assisted self rescue. The individual entering the pit shall remain therein for as brief a period as practical, commensurate with performance of his/her work. After removing the smeared zone, samples shall be obtained with a decontaminated trowel or spoon. [TMD1]

6.8.3.5 Geotechnical Sampling

In addition to the equipment described in Section 6.8.3.2, the following equipment is needed for geotechnical sampling:

- Soil sampling equipment, similar to that used in shallow drilled boring (i.e., thin-walled tube samplers), that can be pushed or driven into the floor of the test pit.
- Suitable driving (e,g., sledge hammer) or pushing (e.g., backhoe bucket) equipment used to advance the sampler into the soil.
- Knives, spatulas, and other suitable devices for trimming hand-carved samples.
- Suitable containers (bags, jars, tubes, boxes, etc.), labels, wax, etc. for holding and safely transporting collected soil samples.
- Geotechnical equipment (pocket penetrometer, torvane, etc.) for field testing collected soil samples for classification and strength properties.

Disturbed grab or bulk geotechnical soil samples may be collected for most soil in the same manner as comparable soil samples for chemical analysis. These collected samples may be stored in jars or plastic-lined sacks (larger samples), which will preserve their moisture content. Smaller samples of this type are usually tested for their index properties to aid in soil identification and classification: larger bulk samples are usually required to perform compaction tests.

Relatively undisturbed samples are usually extracted in cohesive soil using thin-walled tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability, and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe, rather than by a drill rig. Also, the sampler may be extracted from the test pit by excavation around the tube when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit, the requirements described in Section 6.8.3.4 shall be followed. The thin-walled tube sampler shall be

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pushed or driven <u>vertically</u> into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate because the sample will not have the correct orientation.

A sledge hammer or backhoe may be used to drive or push the tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, thus minimizing disturbance to the sample. When using a sledge hammer, it is recommended that the sampler be stabilized using a rope/strap wrench or pipe wrench to remove the person's hands holding the sampler from the strike zone. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hook the sampler to the excavator or backhoe and extract. This means an alternative head will be used as a connection point or that multiple choke hitches will be applied to extract the sampler. If this fails and the excavator can dig deeper without potentially impacting subsurface utilities, excavate the sampler. If this fails or if the excavator cannot be used due to subsurface utilities, hand-excavate to remove the soil from around the sides of the sampler. If hand-excavation requires entry into the test pit, the requirements in Section 6.8.3.4 must be followed. Prepare the sample as described in Steps 9 through 13 in Section 6.2.3, and label, pack and transport the sample in the required manner, as described in SQPs SA-6.3 and SA-6.1.

6.8.4 Backfilling of Trenches and Test Pits

All test pits and excavations must be either backfilled, covered, or otherwise protected at the end of each day. No excavations shall remain open during non-working hours unless adequately covered or otherwise protected.

Before backfilling, the onsite crew may photograph, if required by the project-specific work plan, all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the site logbook. All photographs shall be indexed and maintained as part of the project file for future reference.

After inspection, backfill material shall be returned to the pit under the direction of the FOL. Backfill should be returned to the trench or test pit in 6-inch to 1-foot lifts and compacted with the bucket. Remote controlled tampers or rollers may be lowered into the trench and operated from top side. This procedure will continue to the grade surface. It is recommended that the trench be tracked or rolled in. During excavation, clean soil from the top 2 feet may have been separated to be used to cover the last segments. Where these materials are not clean, it is recommended that clean fill be used for the top cover.

If a low-permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the FOL (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.

6.9 Records

The appropriate sample log sheet (see Attachment A of this SOP) must be completed by the site geologist/sampler for all samples collected. All soil sampling locations should be documented by tying in the location of two or more nearby permanent landmarks (building, telephone pole, fence, etc.) or obtaining GPS coordinates; and shall be noted on the appropriate sample log sheet, site map, or field notebook. Surveying may also be necessary, depending on the project requirements.

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Test pit logs (see Attachment C of this SOP) shall contain a sketch of pit conditions. If the project-specific work plan requires photographs, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Boreholes, test pits, and trenches shall be logged by the field geologist in accordance with SOP GH-1.5.

Other data to be recorded in the field logbook include the following:

- Name and location of job
- Date of boring and excavation
- Approximate surface elevation
- Total depth of boring and excavation
- Dimensions of pit
- Method of sample acquisition
- Type and size of samples
- Soil and rock descriptions
- Photographs if required
- Groundwater levels
- PID/FID/LEL/O₂ meter readings
- · Other pertinent information, such as waste material encountered

In addition, site-specific documentation to be maintained by the SSO and/or Competent Person will be required including:

- Calibration logs
- Excavation inspection checklists
- Soil type classification

7.0 REFERENCES

American Society for Testing and Materials, 1987. <u>ASTM Standards D1587-83 and D1586-84</u>. ASTM Annual Book of Standards. ASTM. Philadelphia, Pennsylvania. Volume 4.08.

NUS Corporation, 1986. Hazardous Material Handling Training Manual.

NUS Corporation and CH2M Hill, August, 1987. Compendium of Field Operation Methods. Prepared for the U.S. EPA.

OSHA, Excavation, Trenching and Shoring 29 CFR 1926.650-653.

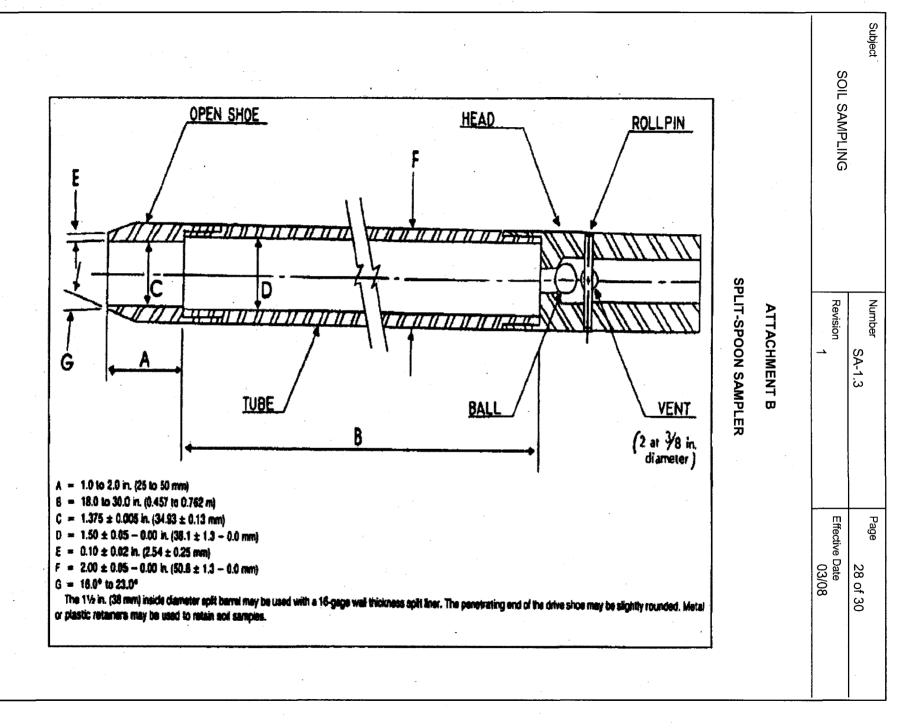
OSHA, Confined Space Entry 29 CFR 1910.146.

USEPA, November 2001. <u>Environmental Investigations Standard Operating Procedures and Quality Assurance Manual</u>.

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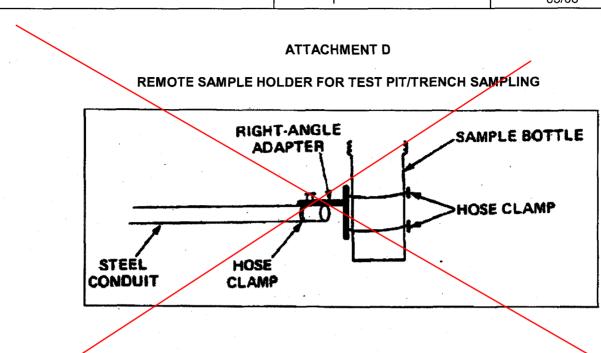
ATTACHMENT A

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TECHNICAL GUIDE

COLLECTING GROUNDWATER SAMPLES FOR PERCHLORATE

Prepared by: DoD Environmental Data Quality Workgroup	Date:
Reviewed by:	Date:
Approved by:	Date:

1.0 Scope & Application

- 1.1 This Technical Guide (TG) has been developed to generate consistency across DoD for the collection and analysis of groundwater samples for perchlorate.
- 1.2 The use of this TG is restricted to individuals familiar with groundwater sampling methods.

2.0 Summary of Method

- 2.1 Low-Flow Purging and Sampling (LFPS) procedures are the preferred method for sampling groundwater wells for perchlorate. However, because of the solubility and stability of perchlorate, samples may be collected using any standard groundwater sampling method that meets the project-specific data quality objectives (DQOs) for sample representativeness.
- 2.2 Materials typically used in the construction of wells or the manufacture of sampling equipment do not affect perchlorate.
- 2.3 Analyses of perchlorate samples must be performed by laboratories that meet the requirements of the *DoD Perchlorate Handbook* and the *DoD Quality Systems Manual for Environmental Laboratories* (DoD-QSM) (http://www.navylabs.navy.mil/ManualsDocs.htm).

3.0 Health and Safety Warnings

- 3.1 This guide does not attempt to address all health and safety issues. The user must determine applicable requirements and establish appropriate health and safety protective measures.
- 3.2 Users of this guide should review the site health and safety plan with specific emphasis placed on hazards related to well sampling tasks. Follow standard safe operating practices.
- 3.3 When working with potentially hazardous materials, follow U.S. EPA, OSHA and Service-specific health and safety regulations, polices and procedures.

4.0 Interferences

- 4.1 The use of disposable/dedicated sampling equipment is recommended to eliminate the potential for sample contamination from documented sources of interferences such as detergents.
- 4.2 If non-disposable/dedicated sampling equipment is used, proper field decontamination techniques must be followed.
- 4.3 If perchlorate is the only target analyte, an acceptable decontamination procedure is to use a non-phosphate soap wash, followed by a deionized water rinse and air drying.
- 4.4 If the investigation includes additional target analytes, then samplers should follow standard decontamination practices for those analytes, except that non-phosphate detergent must be used.
- 4.5 Field samplers must use a rinsate blank to determine that the decontamination has been effective.
- 4.6 Filtration is used to remove microorganisms and suspended solids.

5.0 Equipment and Supplies

5.1 Sampling equipment is typically constructed from Teflon®, stainless steel, PVC, polyethylene, or polypropylene. These materials are all suitable for perchlorate sampling.

6.0 Sample Collection

- 6.1 Standard groundwater sampling equipment and procedures may be used to collect groundwater samples for perchlorate analysis. Dissolved perchlorate will not volatilize, so agitation of the sample or entrained air bubbles from the sampling equipment does not interfere with the analytical results. Standard Low-Flow Purging and Sampling (LFPS) procedures are the preferred method to be used to collect representative groundwater samples. Examples of low-flow purging and sampling procedures are:
 - EPA Region I Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells, July 30, 1996, Revision 2.
 - Puls, R.W. and Barcelona, M.J., "Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedure", U.S. Environmental Protection Agency, Office of Research and Development, Publication # EPA/540/5-95/, pp. 12.
 - ASTM D6771-2, "Standard Practice For Low Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations"
 - 6.1.1 Wells that are continuously pumped or under regular use, so that water in the wells does not have an opportunity to become stagnant (e.g., operating recovery wells, municipal supply wells, and domestic supply wells), can be sampled without additional purging. In such cases the well can be sampled using any appropriate technique. Approval by the regulatory agency may be required.
 - 6.1.2 In those situations where the groundwater conditions and well construction make it appropriate, no-purge sampling methods with devices (e.g. Hydrasleeve and Snap sampler) that are demonstrated to collect representative samples for perchlorate may be used. Approval by the regulatory agency may be required.
- 6.2 If sample collection is required for other analytes, sampling methods and procedures will be dictated by the sampling requirements for the most sensitive parameters.
 - 6.2.1 Samples must be collected in order of decreasing volatility of target analytes. Samples for volatile organic compounds are normally collected first, followed by semivolatile organic compounds and finally inorganic compounds. The sampling order will be specified by the sampling and analysis plan or permit.
- 6.3 Once sampling is complete, all field documentation records and chain-of-custody forms must be completed.
- 6.4 Some sites may be contaminated with light non-aqueous-phase liquids (LNAPLs) or dense non-aqueous-phase liquids (DNAPL), or both, in addition to perchlorate. The presence of DNAPLs and LNAPLs should not affect the sampling procedures for perchlorate. When possible, collect the sample above the DNAPLs or below the LNAPLs.
- 6.5 If there is potential for high-density perchlorate solutions to occur at a site (Perchlorate concentrations > 10,000 ppm) the solution will likely behave like a DNAPL. If monitoring for perchlorate is required in the presence of a high-density perchlorate brine solution, consult the DoD Perchlorate Handbook for additional guidance.

7.0 Sample Handling and Preservation

7.1 Filter the sample through a sterile 0.2µm filter, to remove microorganisms and eliminate

- suspended solids. In cases where it is difficult to filter the sample through the $0.2\mu m$ filter, pre-filtering through a $0.45\mu M$ may be necessary. Collect 80 mL filtered sample in the sterile sample container. After filtering, store the samples with headspace in order to minimize the possibility of anaerobic conditions developing during sample storage.
- 7.2 Samples should be cooled as specified by the applicable method. If no guidance is provided, store the samples at 4 ± 2 °C.
- 7.3 Samples that are stored and collected in the manner described in this TG may be held for a maximum of 28 days before analysis.
- 7.4 Contact your laboratory to clarify all preservation requirements.

8.0 Data and Records Management

- 8.1 Once sampling is complete, all field documentation records and chain-of-custody forms must be completed.
- 8.2 Logbooks should be used and, as with any groundwater sampling event, the logbook should contain such things as: maps showing sample locations, a narrative of the sampling event, a list of all personnel involved with sample collection, water depth, volume purged, and sampling method.

9.0 Field Sample Quality Control and Quality Assurance

- 9.1 The following field quality control samples/checks shall be performed:
 - 9.1.1 Field Duplicate One field duplicate sample must be taken per sampling event, or one per 10 samples, whichever is more frequent.
 - 9.1.2 Field Equipment or Rinse Blank One rinsate blank must be taken per sampling event. (Only required when decontamination of sampling equipment is performed in the field.)
 - 9.1.3 Matrix Spike/Matrix Spike Duplicate One sample per sampling event, or one per 20 samples, whichever is more frequent, must be designated for use as a Matrix Spike/Matrix Spike Duplicate.

10.0 Laboratory Selection, Quality Control, and Quality Assurance

10.1 The laboratory selected to perform the analysis must be approved by a DoD Component and meet the requirements of the National Environmental Laboratory Accreditation Program (NELAP) and the latest version of the DoD QSM. More information about laboratory and method selection is contained in Appendix G of the *DoD Perchlorate Handbook*.

TECHNICAL GUIDE

COLLECTING SURFACE WATER AND WASTEWATER SAMPLES FOR PERCHLORATE

Prepared by:	DoD Environmental Data Quality Workgroup	Date:
Reviewed by:		Date:
Approved by:		Date:

1.0 Scope & Application

- 1.1 This Technical Guide (TG) has been developed to generate consistency across DoD for the collection and analysis of surface water and wastewater samples for perchlorate.
- 1.2 The use of this TG is restricted to individuals trained and experienced in surface water or wastewater sampling methods. It should be used in conjunction with professional judgment, taking site-specific requirements into consideration.
- 1.3 If sampling and testing activities have been requested by a regulatory agency, or are subject to regulatory oversight, then installations should obtain regulatory authority review and comment on the QAPP or SAP.

2.0 Summary of Method

- 2.1 Samples may be collected using the same process specified in the current permit or standard wastewater sampling procedures, as detailed in *Standard Methods for the Examination of Water and Wastewater*, 20th Edition, Section, "1060 Collection and Preservation of Samples".
- 2.2 Materials typically used in the sampling of surface water and wastewater do not affect sampling for perchlorate.
- 2.3 Analyses of perchlorate samples must be performed by laboratories that meet the requirements of the *DoD Perchlorate Handbook* and the *DoD Quality Systems Manual for Environmental Laboratories* (DoD-QSM) (http://www.navylabs.navy.mil/ManualsDocs.htm).

3.0 Health and Safety Warnings

- 3.1 This guide does not attempt to address all health and safety issues. The user must determine applicable requirements and establish appropriate health and safety protective measures.
- 3.2 Users of this guide should review the site health and safety plan with specific emphasis placed on hazards related to surface water and wastewater sampling tasks. Follow standard safe operating practices.
- 3.3 When working with potentially hazardous materials, follow U.S. EPA, OSHA and Service-specific health and safety regulations, policies and procedures.

4.0 Interferences

- 4.1 The use of disposable or dedicated sampling equipment is recommended to eliminate the potential for sample cross-contamination.
- 4.2 If non-disposable/dedicated sampling equipment is used, proper field decontamination techniques must be followed.
- 4.3 If perchlorate is the only target analyte, an acceptable decontamination procedure is to use a non-phosphate soap/detergent wash, followed by a deionized water rinse and air drying.
- 4.4 If the investigation includes additional target analytes, then samplers should follow standard decontamination practices for those analytes, except that non-phosphate detergent must be used.
- 4.5 A rinsate blank should be collected to demonstrate that the decontamination has been effective.

5.0 Equipment and Supplies

5.1 Sampling equipment is typically constructed from stainless steel, PVC, polyethylene, or polypropylene. These materials are all suitable for perchlorate sampling.

6.0 Sample Collection

- 6.1 Standard surface water or wastewater sampling procedures may be used to collect samples for perchlorate analysis (*Standard Methods for the Examination of Water and Wastewater*, 20th Edition, Section, "1060 Collection and Preservation of Samples"). Dissolved perchlorate will not volatilize so agitation of the sample or entrained air bubbles will not interfere with the analytical results.
- 6.2 If sample collection is required for other analytes, sampling methods and procedures will be dictated by the sampling requirements for the most sensitive parameters.
 - 6.2.1 Samples must be collected in order of decreasing volatility of target analytes. Samples for volatile organic compounds are normally collected first, followed by semivolatile organic compounds and finally inorganic compounds. The sampling order will be specified by the sampling and analysis plan or permit.
- 6.3 If waste stream has multiple phases, each phase needs to be collected and analyzed separately.

7.0 Sample Handling and Preservation

- 7.1 Collect 80 mL of sample and store with headspace in order to minimize the possibility of anaerobic conditions developing during sample storage.
- 7.2 Samples should be cooled as specified by the applicable method. If no guidance is provided, store the samples at 4 ± 2 °C.
- 7.3 Samples that are stored and collected in the manner described in this TG may be held for a maximum of 28 days before analysis.
- 7.4 Contact your laboratory to clarify all preservation requirements.

8.0 Data and Records Management

- 8.1 Once sampling is complete, all field documentation records and chain-of-custody forms must be completed.
- 8.2 Logbooks should be used and contain such things as: sample locations, time and date of collection, list of all personnel involved with sample collection and any field measurements take (e.g. pH).

9.0 Field Sample Quality Control and Quality Assurance

9.1 Matrix Spike/Matrix Spike Duplicate – One sample per sampling event, or one per 20 samples per matrix, whichever is more frequent, must be designated for use as a Matrix Spike/Matrix Spike Duplicate.

10.0 Laboratory Selection, Quality Control, and Quality Assurance

10.1 The laboratory selected to perform the analysis must be approved by a DoD Component and meet the requirements of the National Environmental Laboratory Accreditation Program (NELAP) and the latest version of the DoD QSM. More information about laboratory and method selection is contained in Appendix G of the *DoD Perchlorate Handbook*.

TECHNICAL GUIDE

COLLECTING SOLID SAMPLES FOR PERCHLORATE

Prepared by:	DoD Environmental Data Quality Workgroup	Date:
Reviewed by:		Date:
Approved by:		Date:

1.0 Scope & Application

- 1.1 This Technical Guide (TG) has been developed to generate consistency across DoD for the collection and analysis of solid for perchlorate.
- 1.2 The use of this TG is restricted to individuals trained and experienced in soil and sediment sampling methods. It should be used in conjunction with professional judgment, taking site-specific requirements into consideration.
- 1.3 If sampling and testing activities have been requested by a regulatory agency, or are subject to regulatory oversight, then installations should obtain regulatory authority review and comment on the QAPP or SAP. In this case, the collection of split samples is strongly recommended (i.e. where a portion of each sample is sent to a second laboratory).

2.0 Summary of Method

- 2.1 Solid samples for perchlorate can be collected with many types of sampling equipment (e.g. trowels, hand augers, split spoons, direct-push samplers, Ekman dredges, Ponar dredges, Gravity corers).
- 2.2 Care must be taken to ensure that each sample represents the location, sample medium, and depth being evaluated. Poor sampling techniques will produce misleading results and lead to incorrect decisions.
- 2.3 Analysis of perchlorate samples must be performed by laboratories that meet the requirements of the *DoD Perchlorate Handbook* and the *DoD Quality Systems Manual for Environmental Laboratories* (DoD QSM) (http://www.navylabs.navy.mil/ManualsDocs.htm).
- 2.4 Definitive methods (e.g., those employing mass spectrometry (MS)) must be used for the analysis of soil and sediment samples for perchlorate. The use of EPA Method 314.0 or one of its modifications is not appropriate.

3.0 Health and Safety Warnings

- 3.1 This guide does not attempt to address all health and safety issues. The user must determine applicable requirements and establish appropriate health and safety protective measures.
- 3.2 Users of this guide should review the site health and safety plan with specific emphasis placed on hazards related to soil and sediment sampling tasks. Follow standard safe operating practices.
- 3.3 When working in the presence of potentially hazardous materials, energetics or ordnance, follow U.S. EPA, OSHA and Service-specific health and safety regulations, policies and procedures.

4.0 Interferences

- 4.1 The use of disposable or dedicated sampling equipment is recommended to eliminate the potential for sample cross-contamination.
- 4.2 If non-disposable/dedicated sampling equipment is used, proper field decontamination techniques must be followed.
- 4.3 If perchlorate is the only target analyte, an acceptable decontamination procedure is to use a non-phosphate soap/detergent wash, followed by a deionized water rinse and air drying.
- 4.4 If the investigation includes additional target analytes, then samplers should follow standard

- decontamination practices for those analytes, except that non-phosphate detergent must be used.
- 4.5 A rinsate blank to should be collected to demonstrate that the decontamination has been effective.

5.0 Equipment and Supplies

5.1 Sampling equipment is typically constructed from Teflon®, stainless steel, PVC, polyethylene, or polypropylene. These materials are all suitable for perchlorate sampling.

6.0 Sample Collection

- 6.1 Because of its high solubility, it is unlikely that perchlorate will reside in sediments. For this reason, in most situations it will be unnecessary to sample sediments for perchlorate. Sediment sampling may be required in rare situations where large quantities of perchlorate have been released and an evaporative environment exists (waste impoundment associated with munitions demilitarization activities). When this situation exists, standard procedures for sampling sediment should be employed.
- 6.2 Standard soil sampling equipment and procedures may be used to collect samples for perchlorate analysis. Examples include those described in ASTM publication ENVSITE 02, ASTM Standards Related to Environmental Site Characterization, 2nd edition and ASTM D4700-91(1998) Standard Guide for Soil Sampling from the Vadose Zone.
- 6.3 Avoid unusual areas, such as eroded areas, rock outcroppings, and fence lines, unless these features have been specifically designated as sample points in the SAP.
- 6.4 If no contradictory guidance is provided in the QAPP or SAP, remove debris such as sticks, rocks, and vegetation from the soil surface before collecting the samples.
- 6.5 If perchlorate is expected to be distributed homogeneously (e.g. a former wastewater impoundment area at a manufacturing plant) then discrete samples can be taken. If the distribution is expected to be heterogeneous (e.g. retained in propellant matrices, distributed in soil, and not immediately dissolved) or is unknown, then composite (or incremental) soil sampling techniques are recommended. In this case, a sample representing a particular sampling unit (area or volume of soil) should consist of at least five subsamples collected within the sampling unit. Subsamples should be as close to the same size (in terms of mass) as possible.
- 6.6 Following the collection of all subsamples representing a particular sample unit, the sample should be mixed until it achieves a consistent physical appearance.
- 6.7 Well-mixed samples should be placed in clean 4-oz amber glass bottles.

7.0 Sample Handling and Preservation

- 7.1 Samples should be cooled as specified by the applicable method. If no guidance is provided, the samples should be stored at 4 ± 2 °C.
- 7.2 Samples that are stored and collected in the manner described in this TG may be held for a maximum of 28 days before analysis.
- 7.3 Contact your laboratory to clarify all preservation requirements.

8.0 Data and Records Management

8.1 Once sampling is complete, all field documentation records and chain-of-custody forms

must be completed.

8.2 Logbooks should be used and, as with any sampling event, they include: maps showing sample locations, a narrative description of the sampling event, a list of all personnel involved with sample collection, and sampling method.

9.0 Field Sample Quality Control and Quality Assurance

- 9.1 Field Duplicate (Field Split) One field duplicate sample must be taken per sampling event, or one per 10 samples, whichever is more frequent.
- 9.2 Field Equipment or Rinsate Blank One rinsate blank must be taken per sampling event. (Only required when decontamination of sampling equipment is performed in the field.)
- 9.3 Matrix Spike/Matrix Spike Duplicate One sample per matrix per sampling event, or one per 20 samples of the same matrix, whichever is more frequent, must be designated for use as a Matrix Spike/Matrix Spike Duplicate.

10.0 Laboratory Selection, Quality Control, and Quality Assurance

10.1 The laboratory selected to perform the analysis must be approved by a DoD Component and meet the requirements of the National Environmental Laboratory Accreditation Program (NELAP) or the American Association for Laboratory Accreditation (A2LA) and the latest version of the DoD QSM. More information about laboratory and method selection is contained in Appendix G of the *DoD Perchlorate Handbook*.

STANDARD OPERATING PROCEDURES

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Approved

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1.0 PURPOSE

The purpose of this document is to provide general reference information regarding natural attenuation parameter and methodology selection, sample collection, and a general understanding of the sample results.

2.0 SCOPE

This document provides information on selection of appropriate groundwater natural attenuation parameters, selection of sampling methods for these parameters, techniques for onsite field analysis of select parameters, and some basic understanding of the field sample results. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling practices and techniques. To a limited extent, it shall also facilitate the understanding and interpretation of the sampling results. It addresses field procedures for collection of data at sites with organic groundwater contaminants (e.g., chlorinated and petroleum hydrocarbons) to the extent practical. The focus of this document is on natural attenuation, not enhanced bioremediation.

The techniques described shall be followed whenever applicable, noting that site-specific conditions, project-specific objectives, local, state, and federal guidelines may be used as a basis for modification of the procedures noted herein. The intent of this document is to supplement the local, state, and federal guidance documents and manufacturer's analytical methods referenced in Section 6.0. It is not intended for this document to supersede this guidance or information. Please note that natural attenuation is a relatively dynamic science with ongoing research in the science and engineering community. It is important that data collectors and interpreters use the most recent regulatory guidance, which may be updated on a periodic basis from that noted in Section 6.

3.0 GLOSSARY

Aerobe: Bacteria that use oxygen as an electron acceptor.

Anaerobe: Organisms that can use electron acceptors other than molecular oxygen to support their metabolism.

Anoxic groundwater: Groundwater that contains oxygen in concentrations less than about 0.5 mg/L. This term is synonymous with the term anaerobic.

Anthropogenic: Man-made.

Cometabolism: The process in which a compound is fortuitously degraded by an enzyme or cofactor produced during microbial metabolism of another compound.

Daughter product: A compound that results directly from the biotic or abiotic degradation of another. For example, cis-1,2-dichloroethene (cis-1,2-DCE) is a common daughter product of trichloroethene (TCE).

Diffusion: The process whereby molecules move from a region of higher concentration to a region of lower concentration as a result of Brownian motion.

Dispersion: The tendency for a solute to spread from the path that it would be expected to follow under advective transport.

Electron acceptor. A compound capable of accepting electrons during oxidation-reduction reactions. Microorganisms obtain energy by transferring electrons from an electron donor such as an organic compound (or sometimes a reduced inorganic compound such as sulfide) to an electron acceptor. Electron acceptors are compounds that are relatively oxidized and include oxygen, nitrate, iron(III), manganese(IV), sulfate, carbon dioxide, or in some cases chlorinated aliphatic hydrocarbons such as tetrachloroethene (PCE), TCE, DCE and vinyl chloride (VC).

Electron donor. A compound capable of supplying (giving up) electrons during oxidation-reduction reactions. Microorganisms obtain energy by transferring electrons from an electron donor such as an organic compound (or sometimes a reduced inorganic compound such as sulfide) to an

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electron acceptor. Electron donors are compounds that are relatively reduced and include fuel hydrocarbons and native organic carbon.

Metabolic byproduct: A product of the reaction between an electron donor and an electron acceptor.

Metabolic byproducts include volatile fatty acids, daughter products of chlorinated aliphatic hydrocarbons, methane, and chloride.

Oxic groundwater. Groundwater that contains oxygen in concentrations greater than about 0.5 mg/L.

Oxidation/reduction reaction: A chemical or biological reaction wherein an electron is transferred from an electron donor (donor is oxidized) to an electron acceptor (acceptor is reduced).

Predominant terminal electron-accepting process: The electron-accepting process (oxygen reduction, nitrate reduction, iron(III) reduction, etc.) that sequesters the majority of the electron flow in a given system.

Reductive dechlorination: Reduction of a chlorine-containing organic compound via the replacement of chlorine with hydrogen.

Respiration: The process of coupling the oxidation of organic compounds with the reduction of inorganic compounds such as oxygen, nitrate, iron(III), manganese(IV), and sulfate.

Seepage velocity: The average velocity of groundwater in a porous medium.

Substrate: A compound used by microorganisms to obtain energy for growth. The term can refer to either an electron acceptor or an electron donor.

4.0 RESPONSIBILITIES

<u>Project Manager (PM) / Task Order Manager (TOM)</u> - Responsible for ensuring that all field activities are conducted in accordance with this standard operating procedure (SOP).

<u>Project Hydrogeologist or Geochemist</u> - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist or geochemist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

<u>Site Manager (SM) / Field Operations Leader (FOL)</u> - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

<u>Project Geologist</u> - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field sampling technicians or site personnel).

5.0 PROCEDURES

5.1 General

Natural attenuation includes physical, chemical, and biochemical processes affecting the concentrations of dissolved contaminants in groundwater. These processes may include advection, dispersion, volatilization, dilution, sorption to aquifer solids, and/or precipitation or mineralization of compounds. Of greatest importance are those processes that lead to a reduction in contaminant mass (by degrading or destroying contaminants) such as biodegradation. These biochemical processes remove organic contaminants from the aquifer by destruction. Depending on the type of contaminant, particularly the organic contaminant (e.g., petroleum hydrocarbons or chlorinated organic solvents), the biochemical environment in the aquifer will vary. The biochemical environment within the aquifer influences and is influenced by the activities of aquifer microbiota. Specific types of microbiota, working singly or in complex consortia, may use organic contaminants as part of their normal cell functions. Natural

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attenuation monitoring is designed to measure indicators of the biochemical environment within the aquifer and, with direct and indirect lines of evidence and associated chemical concentration data, evaluate the likely fate (i.e., transformation, destruction, dilution, attenuation, etc.) of organic contaminants.

5.2 Planning for Natural Attenuation Sampling

The first step in preparing a natural attenuation investigation is to develop a site-specific conceptual model. The first step in development of this model is the analysis and review of available site-specific characterization data. The development and refinement of this model should be supplemented with additional data as needed. The data should include but is not limited to:

- Geologic and hydrogeologic information in three dimensions
- Nature, extent, and magnitude of contamination
- Location and presence of potential receptors to contamination

Lines of Evidence

Several lines of evidence are used to determine whether natural attenuation is working. The most compelling, primary evidence is decreasing groundwater contaminant concentrations over time. Decreasing concentration trends can be demonstrated in several ways including:

- Isoconcentration maps of the dissolved plume over time wherein the extent of the plume is either stable or decreasing.
- Time series plots of contaminant concentrations within a well illustrating a clear downward trend.
- Contaminant concentration profiles in a series of monitoring wells along a groundwater flow path illustrating decreasing concentrations beyond that attributable to dilution and dispersion.

Secondary, or supporting, lines of evidence include:

- Analytical data showing production and subsequent destruction of primary contaminant breakdown products.
- Geochemical data indicating that the biochemical environment is favorable for the appropriate microbiota.
- Geochemical data that indicate the aquifer microbiota are active.

Monitoring Well Location and Sampling Frequency

The number and locations of wells required to monitor natural attenuation will depend on the physical setting at each location. One possible array of monitoring wells is illustrated in Attachment A. In this scenario, one well is used to monitor conditions upgradient of the source, one well is located in the source area, and several wells are used to define and monitor the downgradient and lateral extent of the dissolved plume. At a minimum, there should be at least one upgradient well (ideally with no contamination present), one well in the source area, one well downgradient from the source area in the dissolved plume, and one downgradient well where contaminant concentrations are below regulatory criteria. Note that the number and locations of monitoring wells will vary depending on the site complexity and site objectives.

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Sampling frequency will be dictated by the ultimate use of the data and site-specific characteristics. Contaminant concentrations may be used to define statistically meaningful trends in contaminant concentrations. The sampling frequency may be defined by the hydrogeologic and/or geochemical conditions as well as the proposed statistical method for data analysis. For example, groundwater flow and contaminant characteristics (e.g., seepage velocity and contaminant loading) may dictate the sample frequency. Regardless of the factors, sampling frequency and duration will need to establish the range of natural chemical variability within the aquifer. After a sufficient amount of data has been collected and the geochemical conditions are understood, the frequency of sampling may be reduced. See Section 5.4 for additional information on sample collection and frequency.

5.3 <u>Selection of Natural Attenuation Parameters</u>

Natural attenuation via biodegradation depends on the nature of the organic contaminants and the oxidation-reduction (redox) environment within the aquifer. Simply stated, if the contaminants are fuels, biodegradation will be most effective if the redox conditions are aerobic or oxidizing. If the contaminants are chlorinated solvents, the biodegradation will be most effective (in the source and near source areas) if redox conditions in the aquifer are anaerobic or reducing.

Several parameters are needed to evaluate whether natural attenuation is taking place and, if so, the rate at which it may be occurring. The primary parameter providing direct evidence of natural attenuation is the aqueous concentrations of parent and daughter volatile organic compounds. More specifically, a decrease in percent products, an increase in daughter products, evidence that the plume is stable or shrinking in size, and overall decline in contaminant concentrations is direct evidence of natural attenuation. Natural attenuation or geochemical parameters that provide information about the redox conditions in the aquifer include:

- Dissolved oxygen
- Nitrate/nitrite
- Dissolved manganese
- Iron
- Sulfate/sulfide
- Methane
- Oxidation-reduction potential (ORP)

Secondary parameters that indicate biological activity in the aquifer and thereby support the natural attenuation evaluation include:

- Dissolved hydrogen
- Alkalinity
- Dissolved carbon dioxide

The concentrations of natural attenuation parameters are used to define the aquifer redox conditions. It is important to record and document the presence or absence (i.e., measurable or not measurable concentration) of certain natural attenuation parameters. The presence or absence of a certain substance may be sufficient to indicate the redox condition within the aquifer. By reference to Attachment B, which illustrates the typical sequence of biologically mediated redox reactions in natural systems, it is apparent that, for example, sulfate reduction (producing dissolved sulfide in groundwater) does not operate in an aerobic environment. Therefore, measurable sulfide should not be present if there is also dissolved oxygen at concentrations indicating an aerobic environment. Attachment B also illustrates the redox potential (measured in millivolts) associated with the redox reactions. ORP readings, also in millivolts, measured during well purging, may be compared with the range of values in Attachment B but with caution. Redox potentials measured with a platinum electrode in natural water samples may be misleading, especially when biologically mediated reactions are important, because many of the critical

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reactions in Attachment B do not generate a response in the electrode. Dissolved hydrogen concentration ranges associated with important redox reactions are also indicated in Attachment B. Because dissolved hydrogen is actually used by microbiota during redox reactions, its concentration may provide an additional indicator of the overall redox condition in the aguifer.

Attachments C and D tabulate the natural attenuation parameters for chlorinated volatile organic compound and petroleum hydrocarbon plumes, respectively. The parameters listed in these tables are organized in order of importance. Parameters selected for analysis shall be determined based on site conditions, project-specific plans, and/or other criteria established for the project. Based on these criteria, it is possible that all of the parameters may be selected.

5.4 Selection of Natural Attenuation Analytical Methods and Procedures

There are many analytical methods available to measure concentrations of the natural attenuation parameters discussed in the previous sections. Attachment E summarizes the sample methodologies, sampling equipment needed, sample volume, container, preservation, and holding time requirements. This table also summarizes the detection limits and the detection ranges for each method. A number of factors should be considered when selecting the appropriate sample analytical methodology including the required parameters, appropriate detection ranges for each compound, cost, and ease of use in the field. For example, when determining the correct methodology for measuring concentrations of total sulfide, the metabolic byproduct of sulfate reducing conditions, it is important to analyze for each of the forms of sulfide (H₂S, S⁻², and HS⁻). Also, when the detection limit of the selected method is exceeded, another method may be considered, or the sampler may be able to dilute the sample (per manufacturer's instructions) to quantify it within the detected range. In terms of cost, some parameters are very time consuming when performed in the field. Without sacrificing sample integrity it may be more appropriate to select a methodology performed in a fixed-base laboratory. Finally, in terms of ease of use, certain field methods are generally easier compared to other methods. Using simpler methods may result in better quality sample results and increased sample repeatability without sacrificing sample integrity. example, in some cases CHEMetrics Titret® Titration Ampule kits may be a good alternative to other hand digital titration methods.

The sample technicians should be aware that based on geochemical conditions recorded in the field, certain geochemical parameters may not have positive detections. For example, if dissolved oxygen concentrations indicate aerobic conditions then it is unlikely that dissolved hydrogen is present (see Section 5.10 for additional information). Another example is alkalinity. If the pH of the groundwater sample is less than 4.5, then it is unlikely that alkalinity will be measurable. Despite the potential for non-detect results, in cases such as those described above, all parameters should be collected in the field based upon project plans. The value in collecting the parameters in the future shall be determined by the project hydrogeologist and/or geochemist in accordance with the projects planning documents data quality objectives (DQO) and the items discussed in Section 5.2.

5.5 Procedures for Sample Collection

Groundwater sample collection for natural attenuation sampling should be performed using low flow purging and sampling techniques. These techniques are described in detail in SOP SA-1.1. Low flow purging and sampling procedures should be used to ensure the collection of a sample that is "representative" of the water present in the aquifer formation. Minimizing stress on the aquifer formation during low flow purging and sample collection ensures that there are minimal alternations to the water chemistry of the sample. The criteria used in the purging process should include minimization of drawdown in the well, stabilization of applicable indicator parameters, and evacuation of a sufficient amount of purge volume in accordance with SOP SA-1.1, project plans, and/or applicable regulatory quidance.

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Groundwater purging and sampling for natural attenuation should be performed using submersible pumps (e.g., bladder pumps) in accordance with SOP SA-1.1. However, in accordance with project plans and applicable regulatory guidance, peristaltic pumps may also be used for this purpose. Limitations of and factors associated with using these devices should be considered (see SOP SA-1.1 for more information). As a result of difficulties in collecting "representative" groundwater samples, bailers should not be used for the collection of natural attenuation samples.

It is critical that disturbance and aeration of samples monitored and collected at the well head are minimized. As a result, a flow-through sampling cell and a direct reading meter shall be used for the measurement of well stabilization indicator parameters (e.g., pH, conductivity, temperature, dissolved oxygen, turbidity, and ORP) at the well head. The pump effluent tubing should be placed at the bottom of the flow-through cell allowing effluent water from the cell to discharge at the top of the meter (above the detector probes) to minimize the agitation of water in the cell.

Documentation of the purging process shall be recorded during and at the completion of purging as discussed in Section 5.8. Immediately following the purging process and before sampling, all applicable indicator parameters must be measured and recorded on the appropriate sample log sheets as discussed in Section 5.8.

After all of the purging requirements have been met, groundwater sampling and natural attenuation data collection can begin. Monitoring wells will be sampled using the same pump and tubing used during well purging.

5.6 <u>Procedures for Field Sample Analysis</u>

Each of the field and fixed-base laboratory sample parameters requires different sampling procedures and holding times. Attachment E presents parameter-specific requirements for sampling, analysis, and storage of all of the parameters and methods sampled as part of natural attenuation analysis.

Due to parameter procedure and holding times, it is important to consider the sequence of sample collection and analysis. Generally speaking, with the exception of volatile organic compounds, field parameters shall be analyzed first followed by fixed-base laboratory sample collection. All samples will be collected in a sequence and manner that minimizes volatilization, oxidation, and/or chemical transformation of compounds. As a result, the following sample and analysis order should be followed:

- 1. Volatile organic compounds
- 2. Dissolved oxygen
- 3. Alkalinity
- Dissolved carbon dioxide
- 5. Dissolved ferrous iron
- 6. Dissolved sulfide (hydrogen sulfide and sulfide)
- 7. Dissolved hydrogen, methane, ethene, and ethane
- 8. Nitrate / Nitrite
- 9. Dissolved manganese
 - 10. Semivolatile organic compounds
 - 11. Other dissolved metals
 - 12. Total metals
 - 13. All other constituents

Field-analyzed parameters should be collected and immediately analyzed directly from the pump effluent per the requirements on Attachment E and manufacturer's recommendations. Care should be taken to minimize any unnecessary disturbance, aeration, or agitation of the sample prior to analysis. It is not acceptable to collect and store samples that are to be analyzed immediately at the well head in a temporary holding container (e.g., open topped pitcher) to be analyzed at a later time.

The manufacturer's procedure manual for each of the field-based analyses shall be maintained in the field during the entire sampling program. The procedures give a detailed explanation of how to perform each particular method and include information on sampling, storage, accuracy checks, interferences, reagents, and apparatus needed to perform each analysis.

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5.7 Procedures for Quality Assurance and Quality Control Field Sample Analysis

Accuracy and precision checks shall be performed to check the performance of the reagents, apparatus, and field analytical procedures per the manufacturer's recommendations. The accuracy checks should include the use of standard solutions (i.e., standard addition), as appropriate. The manufacturer's field test kit manual provides details on how to perform each of the accuracy checks for each parameter where applicable. Refer to Section 6.0 for manufacturer contact information.

Precision checks must include the performance of duplicate analysis. When using a colorimeter, precision checks may also include reagent blank corrections and standard curve adjustments as recommended by the manufacturer. Field duplicate results shall be performed and evaluated for relative percent difference (RPD) at a rate of 1 per 10 samples or as determined by the project plans. The RPD can be calculated as follows:

If the RPD exceeds 50 percent, it is required that the test be performed again to verify the result. The duplicate results shall be documented in the 'Notes' section for that specific parameter on the appropriate sample logsheet (see Section 5.8).

If a colorimeter (e.g., HACH DR-890 or equivalent) is used for parameter analysis, an instrument performance verification test using absorbance standards may also be performed to ensure the meter is providing accurate measurements.

The following table lists examples of the types and frequencies of accuracy checks required for each parameter. Refer to the manufacturer's instructions for information regarding other analyses.

Parameter	Method	Standard Solution	Field Duplicate	Reagent Blank Correction
Alkalinity	CHEMetrics K-9810, -15, -20	None	1 per 10	None
Carbon dioxide	CHEMetrics K-1910, -20, -25	None	1 per 10	None
Dissolved oxygen	CHEMetrics K-7501, -12	None	1 per 10	None
Ferrous iron	HACH DR-890	None	1 per 10	None
Nitrite	HACH DR-890	1 per round	1 per 10	1 per lot
Nitrate	HACH DR-890	1 per round	1 per 10	1 per lot
Sulfide	HACH DR-890	None	1 per 10	None
Hydrogen sulfide	HACH HS-C	None	1 per 10	None

Prior to analysis, the expiration dates of reagents shall be checked. If the reagents have exceeded their expiration date or shelf life, the reagents shall be replaced. If deviations from the applicable analytical procedure are identified, the deviations shall be corrected and the associated samples re-analyzed. If problems are identified with the reagents, apparatus, or procedures, data interferences may be present. Interferences may also be due to other factors (e.g., pH, presence or concentration of other ions, turbidity, temperature, etc.) that may interfere with the sample result. The manufacturer's procedures (e.g., Hach, 1999) should be reviewed prior to analysis to avoid or minimize such interferences. Associated problems

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or suspected interferences shall be documented in the 'Notes' section of the sample logsheet. Often, interferences cannot be avoided. In these cases, the sampler should be aware of these potential interferences and document them properly.

5.8 Documentation Procedures for Field Sample Analysis

Field results shall be properly documented in the field as noted in SOP SA-6.3. The sample log sheet titled "Field Analytical Log Sheet, Geochemical Parameters" shall be prepared for each sample collected and analyzed in the field. A copy of this form can be found as Attachment F of this SOP. Other field log sheets (e.g., low flow purge log sheet, groundwater sample logsheet, etc.) shall also be completed in accordance with SOP SA-6.3.

Specific information shall also be recorded in the project logbook. This information shall include, but is not limited to, the test kit name and model number, lot number and expiration date of the test kit and reagents used, serial number of the instrument (e.g., colorimeter) used for the analysis, and results of the quality assurance and quality control field sample analysis. Because environmental conditions and changes in those conditions may affect the field analytical results, it is important to document the site conditions (weather, temperature, etc.) at the time of sampling in the logbook in accordance with SOP SA-6.3.

5.9 Waste Handling and Disposal

Several of the test kits listed in Attachment E require the use of chemicals and materials that must be properly handled and disposed of in a proper and responsible manner. Refer to specific manufacturer's guidance for handling and disposal practices. See also Section 6.0 for more detailed and complete information. Handling and disposal of these items should be conducted in accordance with all local, state, and federal guidelines.

5.10 Understanding Field Sample Analytical Results

Natural attenuation data interpretation is complicated by the complex inter-relationships of various parameters. The complexity reflects the myriad of biochemical processes. Real-time evaluation of field analytical data can be misleading because a full interpretation often requires combining the field analytical results with fixed-base laboratory results. Regardless, some simple observations and data interpretations in the field may provide insights about the monitoring system or early warnings about sample collection and handling problems.

Data collected from the designated upgradient monitoring well is the baseline from which other interpretations are made. Field analytical data will indicate that the upgradient environment is either oxidizing or reducing. The redox condition within the upgradient area of the aquifer may be natural or impacted by other contaminant source areas (see Section 5.2 for upgradient well selection). Regardless, the redox condition of the upgradient groundwater will influence the source area. Changes in field analytical results from the upgradient well to the source area well will be reflected in samples from monitoring wells further downgradient.

The general characteristics of the two redox environments are summarized in the following table.

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Aerobic/Oxidizing	Anaerobic/Reducing
Measurable dissolved oxygen (>1 to 2 ppm)	No measurable dissolved oxygen (<1 ppm)
Measurable nitrate	No measurable nitrate
No measurable dissolved manganese	Measurable dissolved manganese
 No measurable dissolved ferrous iron 	Measurable dissolved ferrous iron
Measurable dissolved sulfate	No measurable dissolved sulfate
No measurable dissolved sulfide	Measurable dissolved sulfide
No measurable dissolved methane	Measurable dissolved methane
No measurable dissolved hydrogen	Measurable dissolved hydrogen

Transitional environments between these two extremes may have intermediate characteristics and are actually quite common. Because reactions are mediated by biological systems, equilibrium (the basis for the figure in Attachment B) conditions within the aquifer should not be expected. For example, sulfate reduction environments may occur in close proximity to methanogenic environments, and this natural attenuation data may be difficult to interpret. Carefully collected and analyzed field measurements and sample collections for fixed-base laboratory analyses are designed to characterize the aquifer environment along the continuum between strongly aerobic and strongly anaerobic. Because the land surface environment is generally more oxidizing than any groundwater environment, sample handling at the point of collection and analysis is extremely important in preserving the chemical integrity of the groundwater sample.

6.0 REFERENCES

American Society for Testing and Materials (ASTM), 1998. Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites, Designation: E1943-98, West Conshohocken, Pennsylvania.

Chemetrics, 2002, http://www.chemetrics.com.

Department of the Navy, 1998. Technical Guidelines for Evaluating Monitored Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Ground Water at Naval and Marine Corps Facilities, Department of the Navy, September. Prepared by T. H. Weidemeier and F. H. Chappelle.

USEPA (United States Environmental Protection Agency), 1998. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water, EPA/600/R-98/128, Office of Research and Development, Washington, D.C.

Hach Company, 1999. DR-890 Colorimeter Procedures Manual, Product Number 48470-22, Loveland Colorado.

Hach Company, 1999. Digital Titrator (manual), Model Number 16900, Catalog Number 16900-08. Loveland, Colorado.

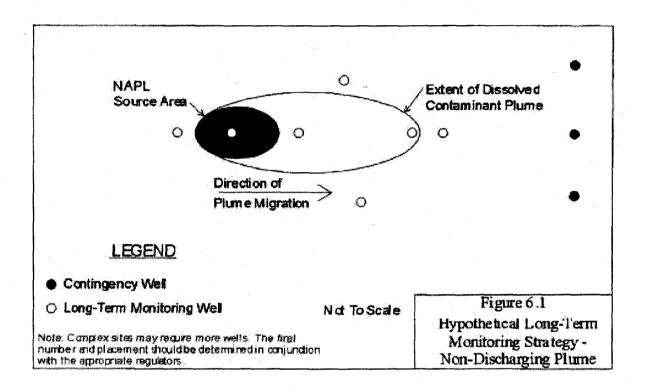
Hach Company, 2002, http://www.hach.com/.

USEPA, 1997. Draft EPA Region 4 Suggested Practices for Evaluation of a Site for Natural Attenuation (Biological Degradation) of Chlorinated Solvents; Version 3.0. November.

USEPA, 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites, USEPA OSWER Directive 9200.4-17P, April 21, 1999

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ATTACHMENT A HYPOTHETICAL LONG-TERM MONITORING STRATEGY



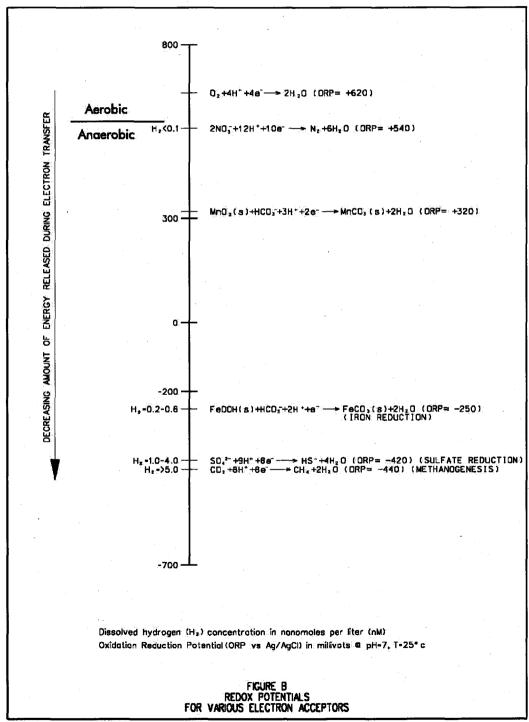
Taken from:

Department of the Navy, 1998, Technical Guidelines for Evaluating Monitored Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Ground Water at Naval and Marine Corps Facilities, Prepared by Todd Weidemeier and Francis Chappelle.

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ATTACHMENT B

REDOX POTENTIALS FOR VARIOUS ELECTRON ACCEPTORS



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ATTACHMENT C

NATURAL ATTENUATION PARAMETERS FOR CHLORINATED VOLATILE ORGANIC COMPOUND PLUMES SCREENING PROCESS SUMMARY FOR REDUCTIVE (ANAEROBIC) DECHLORINATION

Potential Electron Donors	Electron Acceptors:		Reduced Species:		Related Dechlorination Pathway:
	Dissolved Oxygen	⇒	Carbon Dioxide (CO ₂) ~	_	$DCE \rightarrow VC \rightarrow CO_2$
Native total organic carbon (TOC)	Manganese (Mn ⁴⁺)	⇒	Manganese (Mn ²⁺)	./	DCE → VC
Anthropogenic carbon (e.g., leachate)	Nitrate (NO ₃)	⇒	Nitrite (NO ₂)	-	$DCE \to VC$
Fuel hydrocarbons (e.g., BTEX)	Ferric Iron (Fe ³⁺)	\Rightarrow	Ferrous Iron (Fe ²⁺) ~	-	$DCE \to VC \to CO_2$
Lightly chlorinated solvents (DCE/VC)	Sulfate (SO ₄)	˙ ⇒	Sulfide (S ²⁻ , HS ⁻ , H ₂ S) ~		$TCE \to DCE \to VC \to Ethene$
	Carbon Dioxide (CO ₂)	⇒	Methane (CH ₄)	-	$PCE \to TCE \to DCE \to VC \to$
,					Ethene

Geochemical Parameter List:

Parameter	Field or Lab	Rationale	Importance
Volatile organic compounds	ا ا	Source products; daughter products; electron donors (e.g., benzene, toluene, ethylbenzene, and xylene; BTEX)	1
Dissolved oxygen	F	Primary electron acceptor (respiration); an/aerobic indicator	1
Nitrate (and nitrite), dissolved	ForL	Anaerobic electron acceptor (product of nitrate reduction)	1
Manganese, dissolved	ForL	Anaerobic electron acceptor	1
Ferrous Iron (Fe ²⁺)	F	Product of iron reduction	1
Sulfate [and sulfide (S ⁻²)]	ForL	Common anaerobic electron acceptor (product of sulfate reduction)	1
Sulfide (H ₂ S)	F	Common product of sulfate reduction	1
Methane, ethane, ethene	L	Product of methanogenesis; daughter products of reductive dechlorination	1
Chloride	L	Ultimate daughter product of reductive dechlorination	1
TOC - upgradient groundwater	۷/	Electron donor	1
ORP, pH, specific conductance, temperature, turbidity	F	General water quality determination	1
Carbon dioxide (CO ₂)	F	Anaerobic electron acceptor (methanogenesis); biotic respiration indicator	2
Alkalinity/DIC	F	Buffering capacity; biotic respiration indicator	2
Hydrogen, dissolved	L	Fingerprint for characterizing electron acceptor pathway - indicator of what redox is occurring	2
TOC - upgradient soil	L	Input to analytical NA models; quantifies soil-water distribution coefficient and retardation factor	2
Volatile fatty acids	L	Determination of anthropogenic carbon used as an electron donor	3

Importance: 1=Most important; 3=Least important (depending on DQOs, all may be recommended). See Attachment E for details regarding analytical methods.

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ATTACHMENT D

NATURAL ATTENUATION PARAMETERS FOR PETROLEUM HYDROCARBON PLUMES SCREENING PROCESS SUMMARY FOR OXIDATIVE (AEROBIC) DEGRADATION

Parameter	Field or Lab	Rationale	Importance
Volatile organic compounds	. L	Source products; daughter products; electron donors (BTEX)	1
Dissolved oxygen	F	Primary electron acceptor (respiration); an/aerobic indicator	1
Nitrate (and nitrite), dissolved	ForL	Anaerobic electron acceptor (and product of nitrate reduction)	1
Manganese, dissolved	F or L	Anaerobic electron acceptor	1
Ferrous Iron (Fe ²⁺)	F	Product of iron reduction	1
Sulfate [and Sulfide (S ⁻²)]	F or L	Common anaerobic electron acceptor (product of sulfate reduction)	1
Sulfide (H ₂ S)	F	Common product of sulfate reduction	1
TOC - upgradient groundwater	L	Electron donor	1
ORP, pH, specific conductance temperature, turbidity	F	General water quality determination	1
Dissolved methane (CH ₄)	L /	Product of methanogenesis	1
Anions: chloride (CI), nitrate (NO ₃), nitrite (NO ₂), phosphate (PO ₄), sulfate (SO ₄)	L		1
TOC - Upgradient soil	L	Input to analytical NA models; quantifies soil-water distribution coefficient and retardation factor	2
Biological oxygen demand (BOD)	L	Understanding of aquifer oxygen demand	3
Chemical oxygen demand (COD)	L	Understanding of aquifer oxygen demand	3

Importance: 1=Most important; 3=Least important (depending on DQOs, all may be recommended).

See Attachment E for details regarding analytical methods.

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ATTACHMENT E GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUMES, CONTAINERS, PRESERVATION, HOLDING TIMES, AND DETECTION RANGES PAGE 1 OF 4

Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Alkalinity	CHEMetrics K-9810, K-9815, K- 9820 -ASTM D 1067-92 -EPA 310.1		Field. Follow test kit instructions. Avoid agitation and analyze at well head to determine total alkalinity. Filter if turbid (>10 NTU).	10-100 (K-9810) 50-500 (K-9815) 100-1000 (K-9820)	N/A	10 50 100-
Alkalinity	Fixed-base lab -EPA 310.1	N/A	100 to 250 mL in glass or plastic container. Cool to 4°C. Analyze within 14 days. Filter if turbid.	N/A	N/A	N/A
Alkalinity / Dissolved Inorganic Carbon			Field. Follow test kit instructions. Avoid agitation and analyze at well head to determine carbonate, bicarbonate, and hydroxide ions. Filter if turbid as recommended by manufacture. May use a pH meter for colored samples.	10-4000	N/A	10
Arsenic	Fixed-base lab -SW-6010 B	N/A	1 liter glass or polyethylene container, HNO₃ to pH ≤ 2, 6 months.	N/A	N/A	N/A
Biochemical Oxygen Demand	Fixed-base lab -EPA 410.1	N/A	2 liter HDPE. Cool to 4°C. Analyze within 48 hours.	N/A	N/A	N/A
Carbon Dioxide, dissolved	CHEMetrics K-1910, K-1920, K- 1925 -ASTM D 513.82 -SM 4500-CO ₂ -C	Titret® Titration Ampules / Sodium Hydroxide, Phenolphthalein	Field. Follow test kit instructions. Avoid agitation and analyze at well head.	10-100 (K-1910) 100-1000 (K-1920) 250-2500 (K-1925)	N/A	10 100 250
Carbon Dioxide, dissolved	Fixed-base lab - VOA water sample (Vaportech)	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Carbon Dioxide, dissolved	-Microseeps gas stripping cell		Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Carbon Dioxide, dissolved	HACH CA-DT -HACH 8205 -Mod. SM 406	Digital Titration / Sodium Hydroxide, Phenolphthalein	Field. Follow test kit instructions. Do not aerale or agitate. Analyze at well head.	10-1000	N/A	10
Chemical Oxygen Demand	Fixed-base lab -EPA 410.1	N/A	125 mL HDPE. H ₂ SO ₄ to pH <2.0. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Chloride (CI)	Fixed-base lab -EPA 300	N/A	100 to 250 mL in glass or plastic container. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Chlorine - Total (Cl ₂)	HACH DR-850 -HACH 8167 -SM 4500-C1	Colorimeter / DPD Method	Field. Follow test kit instructions.	0.02-2.00	± 0.01 mg/L with a 1.00 mg/L chlorine solution.	1
Conductance, Specific	Field Meter -SW-9050 A	Direct Reading Meter	100 to 250 mL in glass or plastic container. Analyze immediately.	N/A	N/A	N/A
Ethane, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 toi 3 vials by (Vaportech).	N/A	N/A	N/A
Ethane, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A

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GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER, PRESERVATION, HOLDING TIME, AND DETECTION RANGES PAGE 2 OF 4 ATTACHMENT E

Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Ethene, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Ethene, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Fraction Organic Carbon (foc) -Soil Upgradient Saturated Soil	Fixed-base lab -Walk-Black -SW-846 9060	N/A	200 gram glass jar. Cool to 4°C. Analyze within 14 days.	N/A	N/A	N/A
Hydrogen, dissolved	Fixed-base lab -Microseeps or Vapor Tech gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial.	N/A	N/A	N/A
Iron, ferrous (Fe*2)	HACH DR-850 -HACH 8146 -Mod. SM 315 B	Colorimeter 1, 10 Phenanthrolein	Field. Follow test kit instructions. Analyze immediately at well head. Filter if turbid (>10 NTU) as recommended by the manufacture.	0-3.00	±0.017 mg/L with a 2.00 mg/L Fe ²⁺ solution.	0.03
Iron, ferrous (Fe ¹²)	HACH IR-18C -Mod. SM 315 B	Color Disc 1, 10 Phenanthrolein	Field. Follow test kit instructions. Analyze immediately at well head. Filter if turbid (>10 NTU) as recommended by the manufacture.	0-10	N/A	0.2
Iron, total dissolved (Filtered)	Fixed-base lab -SW-846 6010B		250 mL in plastic container. Field filter to 0.45 μ. HCl to pH <2. Cool to 4°C. Analyze within 6 months.	N/A	N/A	N/A
Manganese (Mn ⁴²)	HACH DR-850 -HACH 8034 -CFR 44(116) 34193	Colorimeter / Cold Periodate Oxidation	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-20.0	± 0.18 mg/L with a 10.00 mg/L Mr solution.	0.12
Manganese (Mn ⁺²)	HACH MN-5 -Mod. SM 319 B -CFR 44(116) 34193	Color Disc / Cold Periodate Oxidation	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-3	N/A	0.1
Manganese, total dissolved (Filtered)	Fixed-base lab -SW-846 6010B	N/A	250 mL in plastic container. Field filter to 0.45 μ. HCl to pH <2. Cool to 4°C. Analyze within 6 months.	N/A	N/A	N/A
Methane, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Methane, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Nitrate (NO ₃)	Fixed-base lab -EPA 300	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours.	N/A	N/A	N/A
Nitrate (NO₃`)	HACH DR-850 -HACH 8192 -Mod. EPA 353.2	Colorimeter / Cadmium Reduction	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Pretreatment required if nitrite is present.	0-0.50	± 0.03 mg/L with a 0.25 mg/L of nitrate nitrogen (NO ₃ N) solution.	0.01
Nitrite (NO ₂)	Fixed-base lab -EPA 300	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A

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GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER, PRESERVATION, HOLDING TIME, AND DETECTION RANGES PAGE 3 OF 4 ATTACHMENT E

Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Nitrite (NO ₂)	HACH DR-850 -HACH 8507 -Mod. EPA 354.1 -Mod. SM 419 -CFR 44(85) 25595	Colorimeter / Diazotization	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-0.350	± 0.001 mg/L with a 0.250 mg/L nitrite nitrogen solution.	0.005
Nitrogen , dissolved	Fixed-base lab -Microseeps gas stripping cell - Vaportech VOA water sample	GC-ECD/RGD/FiD Detector	Field bubble-strip sampling required for Microseeps. Ship in glass septum vial (Microseeps) or VOA vial (Vaportech).	N/A	N/A	N/A
Nitrogen, Total Kjeldahl	Fixed-base lab -EPA 351.2	N/A	500 mL plastic/glass container. Cool to 4°C. H₂SO₄ to pH ≤ 2. Analyze within 28 days.	N/A	N/A	N/A
Oxidation Reduction Potential	Field Meter - ASTM D-1498	Direct Reading Meter	Field. Do not aerate. Gently agitate probe using flow over ot flow-through method. Analyze immediately at well head.	N/A	N/A	N/A
Oxygen, dissolved	CHEMetrics K-7501, K-7512 -ASTM D 5543-94 -ASTM D 887-92	CHEMets® Vacuum Vials / Rhodazine D and Indigo Carmine	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-1 (K-7501) 1-12 (K-7512)	N/A	0.025 1
Oxygen, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Oxygen, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FiD Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Oxygen, dissolved	HACH OX-DT -HACH 8215 -SM 4500-O-G	Digital Titration / Azide Modification of Winkler Digital Titration Method	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	1-10	N/A	ŧ
Oxygen, dissolved	HACH DR-850 (AccuVac Ampules) LR HRDO Method	-Indigo Carmine Method -Rhadazine D Method	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-0.8 ppm 0-10 ppm	0.01 ppm 0.1 ppm	N/A
Oxygen, dissolved	Field Meter	Direct Reading Meter	Analyze immediately at well head. Avoid agitation and analyze immediately at well head. Used for well stabilization measurement parameter only.	N/A ,	N/A	N/A
pH	Field Meter -SW 9040B	Direct Reading Meter	Analyze immediately at well head.	N/A	N/A	N/A
Phosphate (ortho)	Fixed-base lab -EPA 300	Ion Chromatography	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Phosphate, potassium	Fixed-base lab -SW-846 6010B	Inductively Coupled Plasma	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Salinity	Field Meter	Direct Reading Meter	Analyze immediately.	N/A	N/A	N/A
Sulfate (SO ₄ ⁻²)	Fixed-base lab	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Sulfate (SO ₄ -2)	HACH DR-850 -HACH 8051 -EPA 375.4	Colorimeter / Turbimetric Sulfa Ver 4	Field. Follow test kit instructions. Filter if turbid as recommended by the manufacture.	0-70	± 0.5 mg/L with a 50 mg/L sulfate solution.	. 4.9
Sulfide (Hydrogen Sulfide, H ₂ S)	HACH HS-C -HACH Proprietary -Mod. SM 426 C	Color Chart / Effervescence of H ₂ S through sulfide reactive paper.	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-5	N/A	· 0.1
Sulfide (S ⁻²)	CHEMetrics K-9510 -SM 4500-S ²	CHEMets® Vacuum Vials / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-1 1-10	N/A	0.1 1

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ATTACHMENT E

GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER, PRESERVATION, HOLDING TIME, AND DETECTION RANGES PAGE 4 OF 4

Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Sulfide (S ⁻²)	Fixed-base lab -EPA 376.1/376.2	N/A	1 liter in plastic container, no headspace. NaOH to pH >9. Cool to 4°C. Avoid agitation and analyze within 7 days.	N/A	N/A	N/A
Sulfide (S ⁻²)	HACH DR-850 -HACH 8131 -SM 4500-S ²	Colorimeter / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head. Pretreatment required for turbid samples as recommended by the manufacture.	0-0.70	± 0.02 mg/L with a 0.73 mg/L sulfide solution	0.01
Sulfide (S ⁻²)	HACH HS-WR -SM 4500-S ²	Color Disc / Methylene Blue	Field. Follow test kit Instructions. Avoid agitation and analyze immediately at well head. Pretreatment required for turbid samples as recommended by the manufacture.	0-11.25	N/A	0.1-2.5
Temperature	Field Meter / Thermometer - E170.1	Direct Reading Meter / Thermometer	Analyze immediately.	N/A	N/A	N/A
Total Organic Carbon (TOC)-Groundwater	Fixed-base lab -E 415.1	N/A	125 mL HDPE. H ₂ SO ₄ to pH < 2.0. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Turbidity	Field Meter - E 180.1	Direct Reading Meter	Analyze immediately.	N/A	. N/A	N/A

N/A = Not applicable.

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ATTACHMENT F

FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS PAGE 1 OF 3

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Project Site						Sample ID N	0.		
Project No.:				•		Sample Loca			
Sampled By				•		Duplicate:	П		
Field Analys				•		Blank:	Ħ		
	Checked as per C	A/QC Che	eklist (init	ials):		7	-		
	A ssistantia								
Date:		Celor	рH	s.c.	Temp.	Turbidity	DO	Salinity	ORP (Eh
Time:		(Visual)	(S.U.)	(mS/cm)	(°C)	(NTU)	(mg/l)	(%)	(+/- mv)
Method:									
SAMPLE CULLE	CTIONANALYSIS I	VF ORMATIO	N:						
ORP (Eh) (+/	- mv)		Electrode I	Make & Mod	lel:				
			Reference	Electrode (d	circle one):	Silver-Silver Chlori	de / Calornel	/ Hydrogen	
Dissolved O									
Equipment Chen	netrics Test Kit					Concentration:		_ppm	
Range Used:	Range	Method	Concentrat	tion ppm					
	0 to 1 ppm	K-7510				Analysis Time:		_	
LL	1 to 12 ppm	K-7512	<u></u>						
Equipment	HACH Digital Titrato	or OX-DT					Analysis Time		=
Range Used:	Range	Sample Vol.	Cartridge	Multiplier		Titration Count	Multiplier	Concentration	긔
	1-5 mg/L	200 ml	0.200 N	0.01			x 0.01	≃mg/L	4
	2-10 mg/L	100 ml	0.200 N	0.02			x 0.02	= mg/L	
Notes:									
0 t D'	l de .								
Carbon Diox									
Equipment Cher	netrics I est Kit					Concentration:		_ppm	
Range Used:	Range	Method	Concentral	tion ppm					
_Ц	10 to 100 ppm	K-1910	 			Analysis Time:		_	
	100 to 1000 ppm	K-1920							
	250 to 2500 ppm	K-1925							
.									
Equipment	HACH Digital Titrato	r CA-DT			i				٦.
Range Used:	Range	Sample Vol.	Cartridge	Multiplier		Titration Count	L	Concentration	닉
-	10-50 mg/L	200 ml	0.3836 N	0.1			x 0.1	≃ mg/L	7
	20-100 mg/L	100 ml	0.3638 N	0.2			x 0.2	≈ mg/L	┪
ㅡ;;;	100-400 mg/L	200 ml	3.638 N	1.0			x 1.0	≈ mg/L	7
Chamble and Address	200-1000 mg/L	100 ml	3.636 N	2.0	duadi 4 m	2nd :	x 2.D	≈ mg/L	
Standard Addition Votes:	ns: 📖 litrant	Molarity:		Digits Requ	urea: 1st.:_	2na.:	3ra.:		
Hvdrogen, d	leenlyed								
	ble strip sampling fiel	d method							
-darbineur ninn	Start stripper at		time)		•				
	End stripper at	(time)						

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Note: Analyte, method, and/or equipment may be deleted from form if not being performed.

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1	

Tetra Tech NUS, I	Inc.	GEC	JCHEMI	CAL PA	ARAMETERS		Page	of	
Project Site I	Name:				Sample ID N	o.:			_
Project No.:				•	Sample Loca				_
Sampled By:			· · · · · · · · · · · · · · · · · · ·	,	Duplicate:				_
Field Analyst				•	Blank:	Ħ			
Alkalinity:									
Equipment Chem	netrics Test Kit				Concentration:		_ppm		
Range Used:	Range	Method	Concentrat	ion ppm					
	10 to 100 ppm	K-9810	<u> </u>		Analysis Time:		_		
	50 to 500 ppm	K-9815	<u> </u>					_	_
	100 to 1000 ppm	K-9820						Filtered:]
Equipment	HACH Digital Titrat	or AL-DT							
Range Used:	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier	Conc	entration	
	10-40 mg/L	100 ml	0.1600 N	0.1	&	x 0.1	=	mg/L	
	40-160 mg/L	25 ml	0.1600 N	0.4		x 0.4		mg/L	
	100-400 mg/L	100 ml	1.600 N	1.0	<u> </u>	x 1.0	_=	mg/L	
	200-800 mg/L	50 mi	1.600 N	2.0		x 2.0	_=	mg/L	
	500-2000 mg/L	20 mi	1.600 N	5.0		x 5.0	=	mg/L	
	1000-4000 mg/L	10 ml	1.600 N	10.0		x 10.0	_=	mg/L	
	Parameter.	Hydroxide	Carb	onate	Bicarbonate]			
	Relationship:					1			
Standard Addition Notes:	ns: 🔲 Titran	nt Molarity:		Digits Requi	ired: 1 st.: 2nd.:	3rd.:			
errous Iron	(Fe ² *):							——————————————————————————————————————	F
Equipment	DR-850	DR-8	Range: 0 -	3.00 mg/L	Concentration:		ppm		
	Program/Module:	500nm	33				_		
			=-		Analysis Time:				
Equipment:	IR-18C Color Whee	si	Range: 0 -	10 mg/l	•		_		
Votes:	Tre to Color Times	31	Range, o -	10 mg/c				Filtered:	1
Hydrogen Su	Iffide (H ₂ S):		Range: 0 -	5 mg/L				Fliescu.	<u>-</u> -
Equipment	HS-C	Other:			Concentration:		ppm		
	Exceeded 5.0 mg/L		or chart		Analysis Time:				
lotes:								····	
Suifide (S²):									
Equipment Chem	etrics Test Kit	·	Range: 0 -	10 mg/L	Concentration:		_ppm		
Range Used:	Range	Method	Concentrat	ion ppm					
	O to 1 ppm	K-9510			Analysis Time:		_		
	1 to 10 ppm	K-9510					_	_	_
	-							Filtered:] .
quipment	DR-850	DR-8	Range: 0 -	0.70 mg/L					
				-					
Program/Module:	610nm	93							
Program/Module:	610nm	93							

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ATTACHMENT F

FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS PAGE 3 OF 3

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.



FIELD ANALYTICAL LOG SHEET

	GEOCHEMICAL PA	RAMETERS	
Tetra Tech NUS, Inc.			Page of
Project Site Name:		Sample ID No.:	
Project No.:		Sample Location:	
Sampled By:		Duplicate:	
Field Analyst:		Blank:	
Sulfate (S0 ₄ 2):			
Equipment DR-850	DR-8 Range: 0 - 70 mg/L	Concentration:	ppm
Program/Module:	_91	Analysis Time:	
	_		_
Standard Solution:	Results:		Filtered:
Standard Additions:	Digits Required: 0.1ml: 0.2n	nl: 0.3ml:	
Notes:	· ·		
Nitrate (NO ₃ '-N):			
Equipment: DR-850	DR-8 Range: 0 - 0.50 mg/L ⁽¹⁾	Concentration:	ppm
Program/Module:	55	Analysis Time:	Filtered: L
_			
Standard Solution: 🔲	Results:	Nitrite Interference Treatment	Reagent Blank Correction:
Standard Additions:	Digits Required: 0.1ml:0.2n	nl: 0.3ml:	*
Alternate forms: NO ₂ NaNO) ₂ mg/L		
Notes (1): If results are over li	imit use dilution method at step	3. 5mi sample 10mi Di resulti	X3. range upto 1.5mg/L
riolos (1). Il rosalits al o over a	THE USE GROWN HOUSE OF SEEP	o, om sample form by room.	, to, tango apro tioniga
Notes:			
Nitrite (NO ₂ -N):		Concentration:	
Equipment DR-850	DR-8 Range: 0 - 0.350 mg/L	Analysis Time:	Filtered:
Program/Module:	62		
Standard Solution:	Results:	Reagent Blank Cor	rection:
Notes:	· · · · · · · · · · · · · · · · · · ·		
Manganese (Min ^{2*}):		Concentration:	ppm
Equipment: DR-850	DR-8 Range: 0 - 20.0 mg/L	Analysis Time:	Filtered:
Program/Module: 525nm	41		
Standard Solution:	Results:	Digestion:	Reagent Blank Correction:
Standard Additions:	Digits Required: 0.1ml: 0.2r	ml: 0.3ml:	
Equipment: HACH MN-5	Range: 0 - 3 mg/L		
Notes:			
QA/QC Checklist:			
All data fields have been complet		· 🗂	
	ited in the SAMPLING DATA block:		
1	ATA block are consistent with the G	Froundwater Sample Log-Sneet:	
Mulitplication is correct for eachM	•		•
	rithin the appropriat@ange Used blo		٦
	ned appropriatly as per manufacture		onto:
	ons, etc.) frequency is appropriate a		ents. L
	s used for Nitrate test if Nitrite was o		п 1
I itie block on each page of form	is initialized by person who perform	ed this UA/UC Checklist:	<u> </u>

CTO 447 030807/P (Appendix D)

STANDARD OPERATING PROCEDURES

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Applicability		

Subject

AIR MONITORING AND SAMPLING

Approved

Prepared

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1.0 PURPOSE

The objective of this Standard Operating Procedure is to specify the proper approach and methodologies to identify and quantify airborne chemical contamination levels through the use of direct reading instrumentation and air sample collection. The results of these activities provide vital information for site characterization and risk assessment considerations.

2.0 SCOPE

Applies to all Tetra Tech NUS site activities where the potential for personnel exposures to respiratory health hazards exists.

3.0 GLOSSARY

<u>Direct Reading Instruments (DRIs)</u> - Instrumentation operating on various detection principles such as flame ionization or photoionization providing real time readings of ambient contaminants in air.

<u>Personal/Area Air Sampling</u> - Personal/area air sampling is conducted utilizing an air sampling pump and a specific collection media to quantify airborne contaminants.

<u>Meteorological Considerations</u> - Meteorological information must be collected on site to properly determine air sampling results, as well as aid in the characterization of contaminant potential plume migration and intensity. This information will also be used to support the selection of sampling locations and determine which samples should be analyzed. The meteorological information will be used to estimate downwind concentration levels based on short-term field levels encountered at the source.

4.0 RESPONSIBILITIES

<u>Project Manager (PM)</u> - Responsible for all aspects of project implementation and direction. The project manager is responsible for providing the necessary resources in support of all air monitoring and sampling applications.

<u>Field Operations Leader (FOL)</u> - Responsible for implementing the air monitoring program as detailed in approved project plans for the specific site. Air monitoring requirements will be included in both the Field Sampling and Analysis Plan (FSAP) and the site-specific Health and Safety Plan (HASP).

<u>Health and Safety Officer (HSO)</u> - The health and safety officer provides technical assistance to the FOL concerning air monitoring and sampling applications, collection methodologies, data interpretations, and establishes action items based on results. This information is further used to assess atmospheric migration of airborne chemical contaminants.

5.0 PROCEDURES

5.1 Introduction

Air monitoring is used to help establish criteria for worker safety, document potential exposures, and determine protective measures for the site personnel and the surrounding public. To accomplish this, it is necessary for an effective air surveillance program to be tailored to meet the conditions found at each work site.

During site operations, data are collected concerning air contaminants representative for site operations. Monitoring for vapors, gases, and particulates is performed using DRIs, air sampling systems, and

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meteorological considerations. DRIs can be used to detect many organics as well as a few inorganics and can provide approximate total concentrations through applications of relative response ratios of contaminants to reference standards. If specific chemicals (organics and inorganics) have been identified, then properly calibrated DRIs can be used for more accurate onsite assessments.

The most accurate method for evaluating any air contaminant is to collect samples and analyze them at a qualified laboratory. Although accurate, this method presents two disadvantages: (1) cost and (2) the time required to obtain results. Analyzing large numbers of laboratory samples can be expensive, especially if results are needed quickly. Onsite laboratories tend to reduce the turnaround time, but unless they can analyze other types of samples, they may also be costly. In emergencies, time is often not available for laboratory analysis of samples either on site or off site.

To obtain air monitoring data rapidly at the site, DRI utilizing flame ionization detectors (FIDs), photoionization detectors (PIDs), and other detection methodology can be used. Some of these may be used as survey instruments or operated as gas chromatographs. As gas chromatographs, these instruments can provide real-time, qualitative/quantitative data when calibrated with standards of known air contaminants. Combined with selective laboratory analysis of samples, they provide a tool for evaluating airborne organic hazards on a real-time basis and at a lower cost than analyzing samples in a laboratory.

5.2 <u>Air Sampling</u>

For more complete information about air contaminants, measurements obtained with DRIs can be supplemented by collecting and analyzing air samples. To assess air contaminants more thoroughly, air sampling devices equipped with appropriate collection media may be placed at various locations throughout the area and on persons with at-risk occupations. These samples provide air quality information for the period of time they are taken, and can indicate contaminant types and concentrations over the sampling period. As a result, careful selection of sampling types, numbers, and locations, by a qualified health and safety professional is essential to obtain representative information. As data is obtained (from the analysis of samples, DRIs, knowledge about materials involved, site operations, and the potential for airborne toxic hazards), adjustments can be in the types of samples, number of samples collected, frequency of sampling, and analysis required. In addition to air samplers, area monitoring stations may also include DRIs equipped with data logging capabilities and operated as continuous air monitors.

Area air sampling locations may be located in various places as required by project and site needs. Area air sampling stations may include, but are not limited to:

- <u>Upwind</u> Industrial operations, vehicle traffic, spills and other contributing sources may cause or otherwise result in the generation of air pollutants. Upwind samples establish background levels
- <u>Support Zone (SZ)</u> Samples may be taken near the command post or other support facilities to ensure that they are, in fact, located in an unaffected area, and that the area remains clean throughout operations at the site.
- Contamination Reduction Zone (CRZ) Air samples may be collected along the decontamination line
 to ensure that decontamination workers are properly protected and that onsite workers are not
 removing their respiratory protective gear in a contaminated area.
- <u>Exclusion Zone</u> (EZ) The Exclusion Zone presents the greatest risk of release/generation of
 contaminants and requires the highest concern for air sampling. The location of sampling stations
 shall be based upon factors such as hot-spots detected by DRIs, types of substances present, and
 potential for airborne contaminants. The data from these stations, in conjunction with intermittent

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walk-around surveys with DRIs, are used to verify the selection of proper levels of worker protection and EZ boundaries as well as to provide a continual record of air contaminants.

<u>Downwind</u> - One or more sampling stations may be located downwind from the site to indicate if any air contaminants are leaving the site. If there are indications of airborne hazards in populated areas, appropriate response action must be taken and additional samplers should be placed downwind. Downwind locations are further determined based on meteorological considerations concerning generation, air plume migration, and intensity.

5.3 <u>Media for Collecting Air Samples</u>

Hazardous material incidents and abandoned waste sites can involve thousands of potentially dangerous substances, such as gases, vapors, and particulates that could become airborne. A variety of media are used to collect these substances. Sampling systems typically include a calibrated air sampling pump, which draws air into selected collection media. It is essential that appropriate, approved air sampling methodologies (such as those published by NIOSH, OSHA, and EPA) be followed for the collection of each specific analyte. Some of the most common types of samples and the collection media used for them are described in the following information:

One of the most common types of collection media is activated carbon which is an excellent adsorbent for most organic vapors. However, other solid adsorbents (such as Tenax, silica gel, and Florisil) are routinely used to sample specific organic compounds or classes of compounds that do not adsorb or desorb well onto activated carbon. To avoid stocking a large number of sorbents for collecting samples for various chemicals, a smaller number is generally chosen for collecting the widest range of materials or for chemicals known to be present. The vapors are collected using an industrial hygiene personal sampling pump with either one sampling port or a manifold capable of simultaneously collecting samples on several sorbent tubes (provided that sampling parameters such as flow rates and sample volumes are satisfied). For example, in a manifold with four sorbent tubes (or on individual pumps with varying flow rates), the tubes might contain:

- Activated carbon to collect vapors of materials with a boiling point above zero degrees Centigrade.
 Common materials collected on activated carbon include organic vapors such as solvents, BTEX, and ketones.
- A porous polymer, such as Tenax or Chromosorb, to collect substances (such as high-molecular-weight hydrocarbons, organophosphorus compounds, and the vapors of certain pesticides) that adsorb poorly onto activated carbon. Some of these porous polymers also absorb organic materials at low ambient temperatures more efficiently than carbon.
- A polar sorbent, such as silica gel, to collect organic vapors (aromatic amines, for example) that exhibit a relatively high dipole moment.
- Another specialty absorbent selected for the specific site. For example, a Florisit tube could be used if polychlorinated biphenyls are expected.
- Liquid impingers aldehydes, ketones, phosgene, phenols.
- Glass fiber filters, membrane filters, Teflon filters Inorganics and other semivolatile compounds.
- Airborne particulates can be either solid or liquid. Examples of common particulate analytes include some metals, fibers such as asbestos, and condensed particulates such as welding fumes. Dusts, fumes, smoke, and fibers are dispersed solids; mists and fogs are dispersed liquids. For air sampling, most particulates are collected using glass fiber, mixed cellulose ester, or polyvinyl chloride filters,

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depending on the filter's ability to collect the subject material and its suitability for laboratory analysis. A cyclone is used to collect particles of respirable size. Atomic Absorption Spectrophotometry, Emission Spectroscopy, Phase Contrast Microscopy, and other techniques are used to analyze various types of particulates. Direct-reading monitors are also used to quantify particulate concentrations, and are usually based on the light-scattering properties of the particulate matter.

5.3.1 Other Methods

Colorimetric detector tubes can also be used with a sampling pump when monitoring for some specific compounds. A detector tube is a vial that contains a chemical preparation that reacts with the measured substance by changing color. Most detector tubes are scale tubes that permit a comparison of the length of the stain to an indicated concentration. Passive organic vapor monitors can be substituted for the active monitoring if they are available for the types of materials suspected to be present at a given site.

5.3.2 NIOSH Methods

The National Institute for Occupational Safety and Health's (NIOSH) <u>Manual of Analytical Methods</u>, 4th ed., contains acceptable methods for collecting and analyzing air samples for a variety of chemical substances. Consult these volumes for specific procedures.

5.4 Collection and Analysis

Collection and analysis of air samples is a multi-faceted task, and is part of the overall air surveillance program. The program is structured to cover the following air pathway analyses:

5.4.1 Selecting Monitoring Constituents

Applications within this program are accomplished using two considerations:

- Air surveillance for specific constituents is based on quantity of the pollutant and the likelihood for vapor release or generation.
- Controlling toxicity These substances, even when represented in limited quantities, present the greatest threat to the public or worker safety, and influence environmental impact.

5.4.2 Specifying Meteorological Considerations

The following factors will influence sample collection:

- Wind direction and speed
- Sigma theta (atmospheric stability)
- Temperature
- Barometric pressure
- Humidity

These factors will provide information essential to properly arrive at accurate air sampling concentration results. This information is also used to identify how airborne chemical contaminants will react for modeling and for monitoring purposes. The results will provide indicators of plume movement, intensity, and dilution.

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5.4.3 Design of Monitoring Network

The air surveillance network is structured to consider:

- Source characteristics (physical state; vapor release and/or generation; emission rates; and disturbance of the source impacting these aspects)
- Receptor sites (receptor sites are monitored and tracked based on priority)
- Meteorological consideration
- · Air modeling input
- Data quality objectives

5.4.4 Air Monitoring Documentation/Data Reduction

5.4.4.1 <u>Air Monitoring Documentation</u>

Elements of the air surveillance program are used to provide documentation valuable to safely performing/containing site activities.

Air monitoring results from DRIs must be recorded, such as on instrument results reporting forms, or in the field logbook. This information, where applicable, will be correlated to air sampling information if/when collected.

Air sampling results for personnel and area measurement efforts must be validated, prior to notifying affected individuals. Personal air sampling results notification is accomplished through verbal or written communications.

Results of air monitoring/sampling activities can be identified on site maps. This information is used to structure operational zones and identify levels of protection.

5.4.4.2 Data Reduction

Data reduction combines and correlates the DRI results, air sampling results, and meteorological information to determine area and source airborne contaminant levels and movement.

All air sampling surveillance efforts must incorporate appropriate and approved NIOSH, OSHA, or EPA analytical methods. These procedures identify specific sample collection media, sampling methodologies, and analytical procedures. Sample analysis for health and safety considerations must be further supported by using American Industrial Hygiene Association accredited laboratories.

5.5 <u>Personnel Monitoring</u>

In addition to area atmospheric sampling, personnel monitoring -- both active and passive -- can be used to sample for air contaminants. Representative workers must be identified, and equipped with appropriate personal sampling systems to determine contaminants at specific locations or for specific work being performed. When sampling devices are placed on workers (generally within 1 foot of the mouth and nose) the results are used to indicate worker exposures.

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5.6 Calibration

As a rule, the entire air sampling system shall be calibrated. Proper pre-and post-calibration activities are essential for correct operation and for accurate data. In some instances, additional calibration during the sampling period may be required. The overall frequency of calibration will depend upon the particular sampling event, including the general handling and use of a given sampling system. Pump mechanisms shall be calibrated after repair, when newly purchased, and following suspected abuse. All DRIs will be calibrated according to manufacturers instructions. All calibration activities for both air monitoring and sampling equipment must be properly documented, such as through the use of a calibration form. This form will be kept on site throughout the life of the project. The calibration log will be submitted as documentation that instrument calibration was performed on a regular basis.

5.7 <u>Meteorological Considerations</u>

Meteorological information is an integral part of an air surveillance program. Data concerning wind speed and direction, temperature, barometric pressure, and humidity (singularly or in combination) are needed for:

- · Selecting air sampling locations
- Calculating accurate air sampling results
- Calculating air dispersion
- Calibrating instruments
- Determining population at risk or environmental exposure from airborne contaminants

Knowledge of wind speed and direction is necessary to effectively place air samplers. In source-oriented ambient air sampling, samplers need to be located downwind (at different distances) of the source and others need to be placed to collect background samples. Shifts in wind direction must be known. Consequently, the samplers must be relocated or corrections made for these shifts. In addition, atmospheric simulation models for predicting contaminant dispersion and concentration need windspeed and direction as inputs for predictive calculations. Information may be needed concerning the frequency and intensity that winds blow from certain directions (windrose data). Consequently, the wind direction must be continually monitored when use of this type of data is contemplated.

Air sampling systems need to be calibrated before use. This must include corrections in the calibration curves for actual temperatures and pressures during the sampling event. After sampling, collected air volumes are also mathematically corrected for temperature and pressure conditions.

Air sampling is sometimes designed to assess population exposure (and frequently potential worker exposure). Air samplers are generally located in population centers, irrespective of wind direction. Even in these instances, however, meteorological data is needed for air dispersion modeling. Models are then used to predict or verify population-oriented sampling results.

Proper data is collected by having meteorological stations on site or by obtaining the information from one or more of several government or private organizations, which routinely collect this data. The choice of how information is obtained depends on the availability of reliable data at the location desired, resources needed to obtain meteorological equipment, accuracy of information needed, and use of information.

The collection, handling, and analysis of air samples is an intricate, involved process. Appropriate methodologies, media, and equipment must be used to collect accurate data. Furthermore, selection of appropriate numbers, types, and locations of samples is essential if the data collected are to be used for personnel exposure criteria. For these reasons, air sampling activities must be coordinated and conducted by properly qualified and experienced industrial hygiene professionals. Air monitoring activities also need to be established and monitored carefully. However, as the proper use of these instruments is

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not as complicated as air sampling, it is commonly acceptable to cross-train capable environmental professionals to use DRIs, with adequate technical support provided by health and safety professionals.

6.0 REFERENCES

Standard Operating Safety Guides, EPA, November 1984. NIOSH Manual of Analytical Methods, 4th Edition.

7.0 ATTACHMENTS

None.

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information on Direct Push Technology (DPT). DPT is designed to collect soil, groundwater, and soil gas samples without using conventional drilling techniques. The advantage of using DPT over conventional drilling includes the generation of little or no drill cuttings, sampling in locations with difficult accessibility, reduced overhead clearance requirements, no fluid introduction during probing, and typical lower costs per sample than with conventional techniques. Disadvantages include a maximum penetration depth of approximately 15 to 40 feet in dense soils (although it may be as much as 60 to 80 feet in certain types of geological environments), reduced capability of obtaining accurate water-level measurements, and the inability to install permanent groundwater monitoring wells. The methods and equipment described herein are for collection of surface and subsurface soil samples and groundwater samples. Soil gas sampling is discussed in SOP SA-2.4.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for DPT. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

<u>Direct Push Technology (DPT)</u> - DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. A primary advantage of DPT over conventional drilling techniques is that DPT results in the generation of little or no investigation derived waste.

Geoprobe® - Geoprobe® is a manufacturer of a hydraulically-powered, percussion/probing machines utilizing DPT to collect subsurface environmental samples. Geoprobe® relies on a relatively small amount of static weight (vehicle) combined with percussion as the energy for advancement of a tool string. The Geoprobe® equipment can be mounted in a multitude of vehicles for access to all types of environmental sites.

<u>HydroPunch™</u> - HydroPunch™ is a manufacturer of stainless steel and Teflon® sampling tools that are capable of collecting representative groundwater and/or soil samples without requiring the installation of a groundwater monitoring well or conventional soil boring. HydroPunch™ is an example of DPT sampling equipment.

<u>Flame Ionization Detector (FID)</u> - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing a flame as the energizing source.

<u>Photo Ionization Detector (PID)</u> - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing ultraviolet radiation as the energizing source.

4.0 RESPONSIBILITIES

<u>Project Manager</u> - The Project Manager is responsible for selecting and/or reviewing the appropriate DPT drilling procedure required to support the project objectives.

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<u>Field Operations Leader (FOL)</u>- The FOL is primarily responsible for performing the DPT in accordance with the project-specific plan.

5.0 SOIL SAMPLING PROCEDURES

5.1 General

The common methodology for the investigation of the vadose zone is soil boring drilling and soil sampling. However, drilling soil borings can be very expensive. Generally the advantage of DPT for subsurface soil sampling is the reduced cost of disposal of drilling cuttings and shorter sampling times.

5.2 Sampling Equipment

Equipment needed for conducting DPT drilling for subsurface soil sampling includes, but is not limited to, the following:

- Geoprobe[®] Sampling Kit
- Cut-resistant gloves
- 4-foot x 1.5-inch diameter macrocore sampler
- Probe sampling adapters
- Roto-hammer with 1.5-inch bit
- Disposable acetate liners for soil macrocore sampler
- Cast aluminum or steel drive points
- Geoprobe® AT-660 Series Large Bore Soil Sampler, or equivalent
- Standard decontamination equipment and solutions

For health and safety equipment and procedures, follow the direction provided in the Safe Work Permit in Attachment 1, or the more detailed directions provided in the project's Health and Safety Plan.

5.3 DPT Sampling Methodology

There are several methods for the collection of soil samples using DPT drilling. The most common method is discussed in the following section. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project-specific plan.

- Macrocore samplers fitted with detachable aluminum or steel drive points are driven into the ground
 using hydraulic pressure. If there is concrete or pavement over a sampling location, a Roto-hammer
 is used to drill a minimum 1.5-inch diameter hole through the surface material. A Roto-hammer may
 also be used if very dense soils are encountered.
- The sampler is advanced continuously in 4-foot intervals or less if desired. No soil cuttings are generated because the soil which is not collected in the sampler is displaced within the formation.
- The sampler is retracted from the hole, and the 4-foot continuous sample is removed from the outer coring tube. The sample is contained within an inner acetate liner.
- Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tail gate is not available, secure the trough on another suitable surface.
- Place the acetate liner containing the soils in the trough.

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- While wearing cut-resistant gloves (constructed of leather or other suitable material), cut the acetate liner through its entire length using the double-bladed knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. Do not attempt to cut the acetate liner while holding it in your hand.
- Field screen the sample with an FID or PID, and observe/examine the sample (according to SOP GH-1.3). If appropriate, transfer the sample to sample bottles for laboratory analysis. If additional volume is required, push an additional boring adjacent to the first and composite/mix the same interval. Field compositing is usually not acceptable for sample requiring volatile organics analysis.
- Once sampling has been completed, the hole is backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch is used to cap holes through paved or concrete areas. All holes should be finished smooth to existing grade.
- In the event the direct push van/truck cannot be driven to a remote location or a sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric operated equipment (e.g., jack hammer).
- Sampling equipment is decontaminated prior to collecting the next sample.

6.0 GROUNDWATER SAMPLING PROCEDURES

6.1 General

The most common methodology for the investigation of groundwater is the installation and sampling of permanent monitoring wells. If only groundwater screening is required, the installation and sampling of temporary well points may be performed. The advantage of temporary well point installation using DPT is reduced cost due to no or minimal disposal of drilling cuttings and well construction materials, and shorter installation/times sampling.

Two disadvantages of DPT drilling for well point installation are:

- In aquifers with low yields, well points may have to be sampled without purging or development.
- If volume requirements are high, this method can be time consuming for low yield aquifers.

6.2 Sampling Equipment

Equipment needed for temporary well installation and sampling using DPT includes, but is not limited, to the following:

- 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point
- Connecting rods
- Roto-hammer with 1.5-inch bit
- Mechanical jack
- 1/4-inch OD polyethylene tubing
- 3/8-inch OD polyethylene tubing
- Peristaltic pump
- Standard decontamination equipment and solutions

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6.3 <u>DPT Temporary Well Point Installation and Sampling Methodology</u>

There are several methods for the installation and sampling of temporary well points using DPT. The most common methodology is discussed below. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project specific plan.

- A 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point attached to connecting rods is
 driven into the ground to the desired depth using a rotary electric hammer or other direct push drill rig.
 If there is concrete or pavement over a sampling location, a Roto-hammer or electric coring machine
 is used to drill a hole through the surface material.
- The well point will be allowed to equilibrate for at least 15 minutes, after which a measurement of the static water level will be taken. The initial measurement of the water level will be used to assess the amount of water which is present in the well point and to determine the amount of silt and sand infiltration that may have occurred.
- The well point will be developed using a peristaltic pump and polyethylene tubing to remove silt and sand which may have entered the well point. The well point is developed by inserting polyethylene tubing to the bottom of the well point and lifting and lowering the tubing slightly while the pump is operating. The pump will be operated at a maximum rate of approximately 2 liters per minute. After removal of sediment from the bottom of the well point, the well point will be vigorously pumped at maximum capacity until discharge water is visibly clear and no further sediments are being generated. Measurements of pH, specific conductance, temperature, and turbidity shall be recorded every 5 to 10 minutes during the purging process. After two consistent readings of pH, specific conductance, temperature and turbidity (±10 percent), the well may be sampled.
- A sample will be collected using the peristaltic pump set at the same or reduced speed as during well development. Samples (with the exception of the samples to be analyzed for volatile organic compounds, VOCs) will be collected directly from the pump discharge. Sample containers for VOCs will be filled by (first shutting off the pump) crimping the discharge end of the sample tubing when filled, removing the inlet end of the sample tubing from the well, suspending the inlet tubing above the vial, and allowing water to fill each vial by gravity flow.
- Once the groundwater sample has been collected, the connecting rods and well point will be removed
 from the hole with the direct push rig hydraulics. The hole will be backfilled with bentonite chips or
 bentonite cement grout, depending upon project requirements. Asphalt or concrete patch will be used
 to cap holes through paved or concrete areas. All holes will be finished smooth to existing grade.
- In the event the direct push van/truck cannot be driven to a remote location or sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric-operated equipment (e.g., jack hammer).
- Decontaminate the equipment before moving to the next location.

7.0 RECORDS

A record of all field procedures, tests, and observations must be recorded in the field logbook, boring logs, and sample log sheets, as needed. Entries should include all pertinent data regarding the investigation. The use of sketches and field landmarks will help to supplement the investigation and evaluation.

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Permit N	lo. Date:		Time: From	toto
	N I: General Job Scope Work limited to the following (descr through direct push technology			ng well drilling and installatio
II.	Required Monitoring Instruments:			
III.	Field Crew:			
۱۷.	On-site Inspection conducted \(\square\)	Yes □ No Initi	als of Inspector	
	N II: General Safety Requirements			TtNUS
V. Level D	Protective equipment required Level D ☑ Level B ☐ Level C ☐ Level A ☐ Detailed on Reverse Minimum Requirements: Sleeved s s, and hearing protection will be wo	Resp F I S Shirt and long pants,	iratory equipment re full face APR Half face APR SKA-PAC SAR Skid Rig safety footwear, an	☐ Escape Pack ☐ SCBA ☐ SCBA ☐ Bottle Trailer ☐ None ☒ d work gloves. Safety glasse:
<u>Halu Hal</u>	s, and hearing protection, will be wo	III WHEN WORKING HEA	or sampling in the	Vicinity of the Diring.
	tions/Exceptions. Chemicals of Concern	Action Level(s)	Response Measures
VII.	Additional Safety Equipment/Proced Hard-hat	Yes □ No Yes □ No Yes ☑ No Yes ☑ No Yes □ No Yes □ No	Safety belt/harnes Radio Barricades Gloves (Type Work/warming reg	☐ Yes ☒ No ☒ Yes ☐ No)☐ Yes ☐ No
VIII.	Procedure review with permit accept Safety shower/eyewash (Location & Daily tail gate meetings	otors Yes NA (Use)	Emergency Evacuation	Yes NA ralarms
IX. S	Site Preparation Utility Clearances obtained for area Physical hazards removed or block Site control boundaries demarcated	s of subsurface inve		☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No
X.	Equipment Preparation Equipment drained/depressurize Equipment purged/cleaned Isolation checklist completed Electrical lockout required/field s Blinds/misalignments/blocks & b Hazardous materials on walls/be	witch testedeeds in place		
XI.	Additional Permits required (Hot wo If yes, complete permit required or	rk, confined space e	ntry)	Yes No
	Special instructions, precautions:	Jontaut Health Scien	ues, r maburgii Ollic	

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NON-RADIOLOGICAL SAMPLE HANDLING

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

2.0 SCOPE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped off site for chemical analysis.

3.0 GLOSSARY

<u>Hazardous Material</u> - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of §172.101 and §172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173. With slight modifications, IATA has adopted DOT "hazardous materials" as IATA "Dangerous Goods."

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (y261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (y261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

<u>Marking</u> - A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i - Not otherwise indicated (may be used interchangeably with n.o.s.).

<u>n.o.s.</u> - Not otherwise specified.

<u>Packaging</u> - A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

<u>Placard</u> - Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

Common Preservatives:

- Hydrochloric Acid HCI
- Sulfuric Acid H₂SO₄
- Nitric Acid HNO₃
- Sodium Hydroxide NaOH

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Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate Na₂S₂O₃

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent.

Reportable Quantity (RQ) - For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR §172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

<u>Sample</u> - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

4.0 RESPONSIBILITIES

<u>Field Operations Leader</u> - Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

<u>Field Samplers</u> - Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the shipper.

5.0 PROCEDURES

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

5.1 Sample Containers

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Attachments A and B show proper containers (as well as other information) per 40 CFR 136. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of sample container orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

5.2 <u>Sample Preservation</u>

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological

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changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

5.2.1 Overview

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. In general, aqueous samples of low-concentration organics (or soil samples of low-or medium-concentration organics) are cooled to 4°C. Medium-concentration aqueous samples, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO₃, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4°C, whereas high-hazard samples are not cooled.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

The FOL is responsible for ensuring that an accurate Chemical Inventory is created and maintained for all hazardous chemicals brought to the work site (see Section 5 of the TtNUS Health and Safety Guidance Manual). Furthermore, the FOL must ensure that a corresponding Material Safety Data Sheet (MSDS) is collected for every substance entered on the site Chemical Inventory, and that all persons using/handling/disposing of these substances review the appropriate MSDS for substances they will work with. The Chemical Inventory and the MSDSs must be maintained at each work site in a location and manner where they are readily-accessible to all personnel.

5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

Acid/Base	Dilution	Concentration	Estimated Amount Required for Preservation
Hydrochloric Acid (HCI)	1 part concentrated HCI: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H ₂ SO ₄)	1 part concentrated H ₂ SO ₄ : 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO ₃)	Undiluted concentrated HNO ₃	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

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- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.
- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).
- Cap sample bottle and seal securely.

Additional considerations are discussed below:

 To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

Continue with proper base preservation of the sample as described above.

• Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

The sample pH is then raised to 9 using the NaOH preservative.

• Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine use a field test kit specially made for this purpose.

If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

5.3 <u>Field Filtration</u>

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed <u>prior to</u> the preservation of samples as described above. General procedures for field filtration are described below:

The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after
collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a
peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by
mechanical peristalsis, the sample travels only through the tubing).

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- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 ml of sample through the filter and discard prior to sample collection.
- Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.

5.4 Sample Packaging and Shipping

Only employees who have successfully completed the TtNUS "Shipping Hazardous Materials" training course are authorized to package and ship hazardous substances. These trained individuals are responsible for performing shipping duties in accordance with this training.

Samples collected for shipment from a site shall be classified as either <u>environmental</u> or <u>hazardous</u> <u>material samples</u>. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)
- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental samples are outlined in the remainder of this section.

5.4.1 Environmental Samples

Environmental samples are packaged as follows:

- Place properly identified sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.
- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic bag (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.
- Pack with enough cushioning materials such as bubble wrap (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.
- If cooling is required (see Attachments A and B), place ice around sample container shoulders, and on top of packing material (minimum of 8 pounds of ice for a medium-size cooler).
- Seal (i.e., tape or tie top in knot) large liner bag.
- The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing the vials for VOC analysis. The COC form should then state how many coolers are included with that shipment.
- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

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Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

6.0 REFERENCES

American Public Health Association, 1981. <u>Standard Methods for the Examination of Water and Wastewater</u>, 15th Edition. APHA, Washington, D.C.

International Air Transport Association (latest issue). <u>Dangerous Goods Regulations</u>, Montreal, Quebec, Canada.

- U.S. Department of Transportation (latest issue). Hazardous Materials Regulations, 49 CFR 171-177.
- U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.
- U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, U.S. EPA-EMSL, Cincinnati, Ohio.

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ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample T	ype and Concentrat	ion	Container ⁽¹⁾	Sample Size	Preservation ⁽²⁾	Holding Time ⁽²⁾
WATER				<u> </u>	<u></u> _	
Organics (GC&GC/MS)	VOC	Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days ⁽⁹⁾
	Extractables SVOCs and pesticide/PCBs)	(Low	Amber glass	2x2 L or 4x1 L.	Cool to 4°C	7 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticide/PCBs)	(Medium	Amber glass	2x2 L or 4x1 L	None	7 days to extraction; 40 days after extraction
Inorganics	Metals	Low	High-density polyethylene	1 L	HNO ₃ to pH ≤2	6 months (Hg-28 days)
		Medium	Wide-mouth glass	16 oz.	None	6 months
	Cyanide	Low	High-density polyethylene	1 L	NaOH to pH>12	14 days
	Cyanide	Medium	Wide-mouth glass	16 oz.	None	14 days
Organic/ Inorganic	High Hazard	<u> </u>	Wide-mouth glass	8 oz.	None	14 days
SOIL						
Organics (GC&GC/MS)	VOC		EnCore Sampler	(3) 5 g Samplers	Cool to 4°C	48 hours to lab preservation
	Extractables SVOCs and pesticides/PCBs)	(Low	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticides/PCBs)	(Medium	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
Inorganics	Low/Medium		Wide-mouth glass	8 oz.	Cool to 4°C	6 months (Hg - 28 days) Cyanide (14 days)
Organic/Inorga nic	High Hazard		Wide-mouth glass	8 oz.	None	NA .
Dioxin/Furan	All		Wide-mouth glass	4 oz.	None	35 days until extraction; 40 days after extraction
TCLP	All		Wide-mouth glass	8 oz.	None	7 days until preparation; analysis as per fraction
AIR						
Volatile Organics	Low/Medium		Charcoal tube - 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4°C	5 days recommended

All glass containers should have Teflon cap liners or septa.
 See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.

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ATTACHMENT B

ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
INORGANIC TESTS:			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia - Nitrogen	P, G	Cool, 4°C; H₂SO₄ to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Chloride	P, G	None required	28 days
Chlorine, Total Residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P, G	Cool, 4°C; NaOH to pH 12; 0.6 g ascorbic acid ⁽⁵⁾	14 days ⁽⁶⁾
Fluoride	Р	None required	28 days
Hardness	P, G	HNO ₃ to pH 2; H ₂ SO ₄ to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H ₂ SO ₄ to pH 2	28 days
Orthophosphate	P, G	Filter immediately; Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenois	G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Residue, Total	P, G	Cool, 4°C	7 days
Residue, Filterable (TDS)	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile (Ash Content)	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days

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ATTACHMENT B ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES PAGE TWO

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾	
INORGANIC TESTS (Cont'd):				
Sulfide	P, G	Cool, 4°C; add zinc acetate plus sodium hydroxide to pH 9	7 days	
Sulfite	P, G	None required	Analyze immediately	
Turbidity	P, G	Cool, 4°C	48 hours	
METALS:(7)				
Chromium VI (Hexachrome)	P, G	Cool, 4°C	24 hours	
Mercury (Hg)	P, G	HNO₃ to pH 2	28 days	
Metals, except Chromium VI and Mercury	P, G	HNO ₃ to pH 2	6 months	
ORGANIC TESTS:(8)		• 1		
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	14 days	
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ HCl to pH 2 ⁽⁹⁾	14 days	
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ adjust pH to 4-5 ⁽¹⁰⁾	14 days	
Phenois ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction	
Benzidines ^{(11), (12)}	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction ⁽¹³⁾	
Phthalate esters ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction	
Nitrosamines ^{(11), (14)}	G, Teflon-lined cap	Cool, 4°C; store in dark; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction	
PCBs ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction	
Nitroaromatics & Isophorone(11)	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ ; store in dark	7 days until extraction; 40 days after extraction	
Polynuclear Aromatic Hydrocarbons (PAHs) ^{(11),(14)}	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ ; store in dark	7 days until extraction; 40 days after extraction	
Haloethers ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction	
Dioxin/Furan (TCDD/TCDF)(11)	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction	

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ATTACHMENT B ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES PAGE THREE

(1) Polyethylene (P): generally 500 ml or Glass (G): generally 1L.

- (2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.
- (3) When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).
- (4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer periods, and has received a variance from the Regional Administrator.

5) Should only be used in the presence of residual chlorine.

- (6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.
- (7) Samples should be filtered immediately on site before adding preservative for dissolved metals.
- (8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

(9) Sample receiving no pH adjustment must be analyzed within 7 days of sampling.

(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

- (11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).
- (12) If 1,2-diphenylthydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.
- (13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
- (14) For the analysis of diphenylnitrosamine, add 0.008% Na₂S₂O₃ and adjust pH to 7-10 with NaOH within 24 hours of sampling.
- (15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% Na₂S₂O₃,

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting field activities.

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all contractor field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

<u>Project Manager (PM)</u> - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

<u>Field Operations Leader (FOL)</u> - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded or referenced (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Time and date of H&S training
- Arrival/departure of equipment
- Time and date of equipment calibration
- Start and/or completion of borehole, trench, monitoring well installation, etc.
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day

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that onsite activities take place which involve contractor or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

The following information must be recorded on the cover of each site logbook:

- Project name
- Contractor project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the field notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook/notebook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided, since they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend upon the subject matter, type of camera (digital or film), and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Once processed, the slides of photographic prints shall be consecutively numbered and labeled according to the logbook/notebook descriptions. The site photographs and associated negatives and/or digitally saved images to compact disks must be docketed into the project's central file.

5.2 <u>Field Notebooks</u>

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

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5.3 Field Forms

Example field forms are listed in Section 6.0 of this SOP. Forms may be altered or revised for project-specific needs contingent upon client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source electronically generated in-house, or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One carbonless copy of the completed COC form is retained by the field crew, one copy is sent to the Project Manager (or designee), while the original is sent to the laboratory. The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing vials for VOC analysis or the cooler with the air bill attached. The air bill should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment C. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the contractor Project Manager). The COC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The Custody seal is an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. The COC seals are signed and dated by the sampler(s) and affixed across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). COC seals may be available from the laboratory; these seals may also be purchased from a supplier.

5.3.1.5 Geochemical Parameters Log Sheets

Field Analytical Log Sheets are used to record geochemical and/or natural attenuation field test results.

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5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

A Groundwater Level Measurement Sheet must be filled out for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The Pumping Test Data Sheet facilitates this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be laid out in advance.

5.3.2.3 Packer Test Report Form

A Packer Test Report Form must be completed for each well upon which a packer test is conducted.

5.3.2.4 Boring Log

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring, or Boring Log is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a PID or FID), these readings must be entered on the boring log at the appropriate depth. The "Remarks" column can be used to subsequently enter the laboratory sample number, the concentration of key analytical results, or other pertinent information. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

5.3.2.7 <u>Miscellaneous Monitoring Well Forms</u>

Monitoring Well Materials Certificate of Conformance should be used as the project directs to document all materials utilized during each monitoring well installation.

The Monitoring Well Development Record should be used as the project directs to document all well development activities.

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5.3.2.8 Miscellaneous Field Forms - QA and Checklists

Container Sample and Inspection Sheet may be used as the project directs each time a container (drum, tank, etc.) is sampled and/or inspected.

QA Sample Log Sheet may be used at the project directs each time a QA sample is colleted, such as Rinsate Blank, Source Blank, etc.

Field Task Modification Request (FTMR) will be prepared for all deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Copies of all FTMRs will be maintained with the onsite planning documents and originals will be placed in the final evidence file.

The Field Project Daily Activities Check List and Field Project Pre-Mobilization Checklist may be used during both the planning and field effort to assure that all necessary tasks are planned for and completed. These two forms are not a requirement but a useful tool for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used or in accordance with the manufacturer's recommendations.

5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

5.4.1 Daily Activities Report

To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

5.4.1.1 Description

The Daily Activities Report (DAR) documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. An example DAR form can be found in Appendix E.

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5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to summaries described herein, other summary reports may also be contractually required.

6.0 SAMPLE FIELD FORMS

Example field forms can be found in Attachment C of the Master SAP. Groundwater Sample Log Sheet Surface Water Sample Log Sheet Soil/Sediment Sample Log Sheet **Groundwater Level Measurement Sheet Pumping Test Data Sheet** Packer Test Report Form **Boring Log** Monitoring Well Construction Bedrock Flush Mount Monitoring Well Construction Bedrock Open Hole Monitoring Well Construction Bedrock Stick Up Monitoring Well Construction Confining Layer Monitoring Well Construction Overburden Flush Mount Monitoring Well Construction Overburden Stick Up Test Pit Log Monitoring Well Development Record **Daily Activities Record** Field Task Modification Request Hydraulic Conductivity Test Data Sheet Low Flow Purge Data Sheet **Equipment Calibration Log**

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ATTACHMENT A TYPICAL SITE LOGBOOK ENTRY

START TI	IME:	DATE:
SITE LEAD		
PERSONI CC	ONTRACTOR DRILLER	R SITE VISITORS
WEATHE	R: Clear, 68°F, 2-5 mph wind from SE	
ACTIVITIE	ES:	
1.	Steam jenney and fire hoses were set up.	
2.	Notebook, No. 1, page 29-30, for details of one see sample logbook, page 42. Drilling active	geologist was See Geologist's drilling activity. Sample No. 123-21-S4 collected vities completed at 11:50 and a 4-inch stainless pok, No. 1, page 31, and well construction details
3.	Drilling rig No. 2 steam-cleaned at decon-	ntamination pit. Then set up at location of
4.	Well drilled. Rig geologist was No. 2, page for details of drilling active and 123-22-S3 collected; see sample logboom	vities. Sample numbers 123-22-S1, 123-22-S2
5.		drums were filled in the flushing stage. The well or 1 hour. At the end of the hour, water pumped
6.	EPA remedial project manger arrives on site a	at 14:25 hours.
7.	Large dump truck arrives at 14:45 and is ste over test pit	eam-cleaned. Backhoe and dump truck set up
8.	See Geologist's Note	aced in dump truck. Rig geologist was tebook, No.1, page 32, for details of test pit
		o samples taken for chemical analysis. Due to pit resulted in a very soft and wet area. A off.
9.	Express carrier picked up samples (see	e Sample Logbook, pages 42 through 45) at 3:22 hours. All personnel off site, gate locked.
	Field Operations	Leader

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ATTACHMENT B

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ATTACHMENT D

CHAIN-OF-CUSTODY SEAL

Signature enutangië	CUSTODY SEAL
ejad	Date
CUSTODY SEAL	Signature

STANDARD OPERATING PROCEDURES

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Applicability

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Prepared

Subject DECONTAMINATION OF FIELD EQUIPMENT

Approved

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1.0 PURPOSE

Decontamination is the process of removing and/or neutralizing site contaminants that have contacted and/or accumulated on equipment. The purpose of this Standard Operating Procedure (SOP) is to protect site personnel, the general public, and the environment while preserving or maintaining sample integrity. It is further intended through this procedure to describe the steps necessary for proper decontamination of drilling equipment, earth-moving equipment, chemical sampling equipment and field operation and analytical equipment.

2.0 SCOPE AND APPLICABILITY

This procedure applies to all equipment used to provide access to/acquire environmental samples that may have become contaminated through direct contact with contaminated media including air, water, and soil. This equipment includes drilling and heavy equipment and chemical sampling and field analytical equipment. Where technologically and economically feasible, single-use sealed disposable equipment will be employed to minimize the potential for cross-contamination. This SOP also provides general reference information on the control of contaminated materials.

Decontamination methods and equipment requirements may differ from one project to another. General equipment items are specified in Section 6.0, but project-specific equipment must be obtained to address the project-specific decontamination procedures presented in Section 7.0 and applicable subsections.

3.0 GLOSSARY

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

<u>Decontamination Solution</u> - A solution selected/identified in the Health and Safety Plan or Project-Specific Quality Assurance Plan. The solution is selected and employed as directed by the project chemist/health and safety professional.

<u>Deionized Water (DI)</u> - Tap water that has been treated by passing through a standard deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet College of American Pathologists (CAP) and National Committee for Clinical Laboratory Standards (NCCLS) specifications for reagent-grade Type I water.

<u>Potable Water</u> - Tap water from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

<u>Pressure Washing</u> - Process employing a high-pressure pump and nozzle configuration to create a high-pressure spray of potable water. High-pressure spray is employed to remove solids from equipment.

<u>Solvent</u> – A liquid in which solid chemicals or other liquids are dissolved. The solvent of choice is pesticide-grade isopropanol. Use of other solvents (methanol, acetone, or hexane) may be required for particular projects or for a particular purpose (e.g., removal of concentrated waste) and must be justified in the project planning documents. For example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

<u>Steam Pressure Washing</u> - A cleaning method employing a high-pressure spray of heated potable water to remove various organic/inorganic chemicals from equipment.

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4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

<u>Project Manager</u> - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

<u>Decontamination Personnel</u> - Individuals assigned the task of decontamination. It is the responsibility of these individuals to understand the use and application of the decontamination process and solutions as well as the monitoring of that process to ensure that it is working properly. This is accomplished through visual evaluation, monitoring instrument scanning of decontaminated items, and/or through the collection of rinsate blanks to verify contaminant removal.

<u>Field Operations Leader (FOL)</u> - Responsible for the implementation of project-specific planning documents. This includes on-site verification that all field activities are performed in compliance with approved SOPs or as otherwise dictated by the approved project plan(s). The FOL is also responsible for the completion and accuracy of all field documentation.

<u>Site Safety Officer (SSO)</u> - Exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on site (as part of the equipment inspection), leaving the site, and moving between locations is required to go through a decontamination evaluation. This is accomplished through visual examination and/or instrument screening to determine the effectiveness of the decontamination process. Improper or incomplete decontamination is sufficient to restrict equipment from entering the site, exiting the site, or moving to a new location on the site until the objectives are successfully completed.

General personnel qualifications for decontamination activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate decontamination procedures.

5.0 HEALTH AND SAFETY

In addition to the health and safety issues and reminders specified in subsections of this SOP, the following considerations and requirements must be observed as SOPs for field equipment decontamination activities:

- If any solvents or hazardous chemicals (e.g., isopropyl alcohol) are to be used in equipment
 decontamination activities, the FOL must first obtain the manufacturer's/supplier's Material Safety
 Data Sheet (MSDS) and assure that it is reviewed by all users (prior to its use), added to the site
 Hazardous Chemical Inventory, and maintained on site as part of the project Hazard Communication
 Program.
- Review and observe specific health and safety requirements (e.g., personal protective equipment [PPE]) specified in the project-specific health and safety plan for this activity.

6.0 EQUIPMENT LIST

- Wood for decontamination pad construction, when applicable (see Section 7.1).
- Tools for constructing decontamination pad frame, when applicable (see Section 7.1).

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- Visqueen sheeting or comparable material to cover decontamination pad frame, when applicable (see Section 7.1).
- Wash/drying racks for auger flights and drill/drive rods, when applicable (see Section 7.2).
- PPE as specified in the project health and safety plan.
- Soap and water for washing and rinsing.
- Deionized water for final rinsing.
- Solvents (e.g., pesticide-grade isopropanol) for rinsing (see applicable portions of Section 7.2).
- Tubs, buckets, etc. for containerizing rinse water (see applicable portions of Section 7.2).
- Sample bottles for collecting rinsate blanks (see Section 7.2).
- Calibrated photoionization detector (PID) or flame ionization detector (FID) to monitor decontaminated equipment for organic vapors generated through the existence of residual contamination or the presence of decontamination solvent remaining after the piece was rinsed.
- Aluminum foil or clear clean plastic bag for covering cleaned equipment (see applicable portions of Section 7.2).
- · Paper towels or cloths for wiping.
- Brushes, scrapers, or other hand tools useful for removing solid materials from equipment.
- Clear plastic wrap for covering or wrapping large decontaminated equipment items (see Section 7.2.2).
- Drum-moving equipment for moving filled waste drums (optional) (see Section 7.3).
- Drum labels for waste drums (see Attachment A).

7.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants, neutralization of contaminants, or isolation of contaminants. To accomplish this activity, preparation is required including site preparation, equipment selection, and evaluation of the decontamination requirements and processes. Site contaminant types, concentrations, and media types are primary drivers in the selection of the types of decontamination and where it will be conducted. For purposes of this SOP, discussion is limited to decontamination procedures for general environmental investigations.

Decontamination processes will be performed at the location(s) specified in project-specific planning documents. Typical decontamination locations include the following:

- Temporary decontamination pads/facilities
- Sample locations
- Centralized decontamination pad/facilities
- Combination of some or all of the above

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The following discussion includes general considerations for the decontamination process. Specific construction and implementation procedures will be as specified in the project-specific planning documents and/or may be as dictated by site-specific conditions as long as the intent of the requirements in the planning documents is met. This intent is to contain any residual fluids and solids generated through the decontamination process.

7.1 Decontamination Pad Design/Construction Considerations

7.1.1 Temporary Decontamination Pads

Temporary decontamination pads may be constructed at satellite locations within the site area in support of temporary work areas. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth-moving equipment but can be employed for smaller articles.

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soil generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations:

- Site location The decontamination site selected should be far enough from the work site to maximize decontamination effectiveness while minimizing travel distance. The location of the decontamination site shall be selected to provide, in the judgment of the FOL or FOL designee, compliance with as many of the following characteristics as practicable:
 - Well removed from pedestrian/vehicle thoroughfares.
 - Avoidance of areas where control/custody cannot be maintained.
 - Avoidance of areas where potential releases of contaminated media or decontamination fluids may be compounded through access to storm water transport systems, streams, or other potentially sensitive areas.
 - Avoidance of potentially contaminated areas.
 - Avoidance of areas too close to the ongoing operation, where cross-contamination may occur.

The selected decontamination site should include the following, where possible:

- Areas where potable water and electricity are provided.

Safety Reminder

When utilizing electrical power sources, either hard-wired or portable-generated sources, ensure that:

- All power is routed through a Ground Fault Circuit Interrupter (GFCI).
- All power cords are in good condition (no physical damage), rated for the intended energy load, and designated for outdoor use.

In situations where accomplishing these elements is not possible, it will be necessary to implement a site electrical grounding program.

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- Areas where support activities such as removing decontamination waters soil and sediment are possible without entering an active exclusion zone.
- Areas that offer sufficient size to carry out the specific decontamination sequence.
- Decontamination pad (decon pad) The decon pad shall be constructed to meet the following characteristics:
 - Size The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination. The size should permit these movements utilizing pressure/steam washer wands and hoses and minimizing splash due to work in close quarters.
 - Slope An adequate slope will be constructed to permit the collection of water and potentially contaminated soil within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks. Because the pad will be sloped, place a light coating of sand over the plastic to minimize potential slips and falls. See the text about liners below.
 - Sidewalls The sidewalls shall be at least 6 inches in height (or as high as possible if 6 inches is not achievable) to provide adequate containment for wash waters and soil. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls may be constructed of wood, inflatables, sand bags, etc. to permit containment. Splash guards are typically wood frames with Visqueen coverings to control overspray.
 - Liner Depending on the types of equipment and decontamination method to be used, the liner should be of sufficient thickness to provide a puncture-resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. The desired thickness may be achieved through layering materials of lighter construction. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner, a light coating of sand shall be applied to provide traction as necessary.
 - Wash/drying racks Auger flights, drill/drive rods, and similar equipment require racks positioned
 off of the ground to permit these articles to be washed, drained, and dried while secured from
 falling during this process.

For decontamination of direct-push technology (DPT) equipment, the pad may be as simple as a mortar tub containing buckets of soapy water for washing and an empty bucket to capture rinse waters. Decontamination may be conducted at the rear of the rig to permit rapid tool exchange.

- Maintenance Maintain the decontamination area by:
 - Periodically clearing the work area of standing water, soil, and debris, and coiling hoses to aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross-contamination.
 - Regularly changing the decontamination fluids to ensure proper cleaning and prevent cross-contamination.

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- PPE - Periodically evaluate the condition of, and maintain the decontamination equipment, including regular cleaning of face shields and safety glasses. This is critical to ensuring the safety of decontamination personnel and the integrity of the decontamination process, and it will ensure that equipment is functioning properly.

7.1.2 Decontamination Activities at Drill Rigs/DPT Units

During subsurface sampling activities including drilling and DPT activities, decontamination of drive rods, Macro Core Samplers, split spoons, etc. is typically conducted at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.

Buckets shall be placed within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected environmental media. Drying racks shall be employed as directed for temporary pads to permit parts to dry and be evaluated prior to use/reuse. Methodology regarding this activity is provided in Section 7.2.

7.1.3 Decontamination Activities at Remote Sample Locations

When sampling at remote locations, sampling equipment such as trowels and pumps/tubing should be evacuated of potentially contaminated media to the extent possible. This equipment should be wrapped in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition. Flushing and cleaning of single-use equipment such as disposable trowels, tubing, and surgeon's gloves may allow disposal of this equipment after visible soil and water remnants have been removed.

7.2 Equipment Decontamination Procedures

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

7.2.1 Monitoring Well Sampling Equipment

- 7.2.1.1 Groundwater sampling equipment This includes pumps inserted into monitoring wells such as bladder pumps, Whale pumps, and Redi-Flo pumps and reusable bailers, etc.
- 1. Evacuate to the extent possible, any purge water within the pump/bailer.
- 2. Scrub using soap and water and/or steam clean the outside of the pump/bailer and, if applicable, the pump tubing.
- 3. Insert the pump and tubing/bailer into a clean container of soapy water. Pump/run a sufficient amount of soapy water through the pump/bailer to flush out any residual well water. After the pump is flushed, circulate soapy water through the pump to ensure that the internal components are thoroughly flushed.
- 4. Remove the pump and tubing/bailer from the container
- 5. Rinse external pump components using tap water.
- 6. Insert the pump and tubing/bailer into a clean container of tap water. Pump/run a sufficient amount of tap water through the pump/bailer to evacuate all of the soapy water (until clear).

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CAUTION

Do not rinse PE, PVC, and associated tubing with solvents –
Use the procedures defined in the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 7 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

- 7. If groundwater contains or is suspected to contain oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment to be cleaned with pesticide-grade isopropanol.
- 8. Pass deionized water through the hose to flush out the tap water and solvent residue as applicable.
- 9. Drain residual deionized water to the extent possible.
- 10. Allow components of the equipment to air dry.
- 11. For bladder pumps, disassemble the pump and wash the internal components with soap and water, then rinse with tap water, isopropanol, and deionized water and allow to dry. After the parts are dry, conduct a visual inspection and a monitoring instrument scan to ensure that potential contaminants and all decontamination solvent have been removed. Collect a rinsate blank in accordance with the project-specific planning documents to ensure that the decontamination process is functioning as intended. The typical frequency of collection for rinsate blanks is 1 per 20 field samples. In addition, wipe samples or field tests such as UV light may be used.
- 12. Wrap pump/bailer in aluminum foil or a clear clean plastic bag for storage.

SAFETY REMINDER

Remember when handling powered equipment to disconnect the power source and render the equipment to a zero energy state (both potential and kinetic) before opening valves, disconnecting lines, etc.

7.2.1.2 Electronic Water Level Indicators/Sounders/Tapes

During water level measurements, rinsing the extracted tape and probe with deionized water and wiping the surface of the extracted tape between locations is acceptable. However, periodic full decontamination should be conducted as follows:

- 1. Wash with soap and water
- 2. Rinse with tap water
- 3. Rinse with deionized water

NOTE

In situations where oil, grease, free product, other hard to remove materials are encountered, probes and exposed tapes should be washed in hot soapy water. If probes or tapes cannot be satisfactorily decontaminated (they are still stained, discolored, etc.), they should be removed from service.

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7.2.1.3 Miscellaneous Equipment

Miscellaneous equipment including analytical equipment (water quality testing equipment) shall be cleaned per manufacturers' instructions. This generally includes wiping the sensor housing and rinsing with tap and deionized water.

Coolers/shipping containers employed to ship samples are received from the laboratory in a variety of conditions including marginal to extremely poor. Coolers shall be evaluated prior to use for the following:

- Structural integrity Coolers missing handles or having breaks in the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples in the cooler(s) provided is too great and request a replacement unit.
- Cleanliness As per protocol, only volatile organic samples are accompanied by a trip blank. If a
 cooler's cleanliness is in question (visibly dirty/stained) or if there are noticeable odors, the cooler
 should be decontaminated prior to use as follows:
 - 1. Wash with soap and water
 - 2. Rinse with tap water
 - 3. Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and ask the cooler provider (e.g., the analytical laboratory) to provide a replacement unit.

7.2.2 Downhole Drilling Equipment

This includes any portion of the drill rig that is over the borehole, including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. The following procedure is to be employed prior to initiating the drilling/sampling activity, then between locations:

CAUTION

Exercise care when using scrapers to remove soil and debris from downhole drilling equipment. Inadvertent slips of scrapers have resulted in cuts, scrapes, and injured knuckles, so use scrapers carefully when removing soil from these items.

- 1. Remove loose soil using shovels, scrapers, etc.
- 2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment being decontaminated.

CAUTION

In Step 3, do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

3. Rinse the equipment with tap water, where applicable (steam cleaning and pressure washing incorporate rinsing as part of the process).

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- 4. If the equipment has directly or indirectly contacted contaminated sample media and is known or suspected of being contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse equipment with pesticide-grade isopropanol
- 5. To the extent possible, allow components to air dry.
- 6. If the decontaminated equipment is to be used immediately after decontamination, screen it with a calibrated photoionization detector (PID)/flame ionization detector (FID) to ensure that all contaminants and possible decontamination solvents (if they were used) have been adequately removed.
- 7. Wrap or cover equipment in clear plastic until it is time to be used.

SAFETY REMINDER

Even when equipment is disconnected from power sources, dangers such as the following may persist:

- <u>Falls</u> An auger flight standing on its end may fall and injure someone. Secure all loose articles to prevent heavy articles from falling onto people or equipment.
- <u>Burns</u> Steam cleaner water is heated to more than 212 °F and exhibits thermal energy that can cause burns. Prevent contact of skin with hot water or surfaces.

High water pressure - Pressure washer discharge can have 2,000 to 4,000 psi of water pressure. Water under this amount of pressure can rupture skin and other human tissues. Water at 4,000 psi exiting a 0° tip can be dangerous because of its relatively high cutting power. The exit velocity and cutting power of the water are reduced when exiting a 40° fan tip, but damage to soft tissues is still possible.

In general, follow the rules below to avoid injury, equipment damage, or incomplete decontamination:

- 1. Read the operating manual and follow the manufacturers' recommended safety practices before operating pressure washers and steam cleaners.
- 2. Never point the pressure washer or steam cleaner at another person or use to clean your boots or other parts of your body. Water lacerations and burns may appear to be minor at first but can be life threatening. Do not attempt to hold small parts in your hand while washing them with high-temperature or high-pressure water.
- 3. Always wear PPE as specified in the HASP such as:
 - Hard hat, safety glasses, splash shield, impermeable apron or splash suit, and hearing protection.
 Remember that excessive noise is a hazard when operating gas-powered engines and electrically driven pressure washers. PPE will be identified in your project specific planning documents.
- 4. Inspect each device before use. An inspection checklist will be provided in the project-specific planning documents. If it is a rented device, safety measures are typically provided by the vendor. In all cases, if you are not familiar with the operation of a pressure washer/steam cleaner, do not operate it until you obtain and thoroughly review operating instructions and recommended safety practices.
- 5. Do not modify equipment unless the manufacturer has approved the modifications.

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7.2.3 Soil/Sediment Sampling Equipment

This section applies to soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

- 1. Remove all loose soil from the equipment through manual means.
- 2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment.
- 3. Rinse the equipment with tap water.

CAUTION

Do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

- 4. If the equipment is contaminated or suspected to be contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment with pesticide-grade isopropanol.
- 5. Rinse the equipment with deionized water.
- 6. To the extent possible, allow components to air dry.
- 7. If the equipment is to be used immediately after decontamination, screen it with a calibrated PID/FID to ensure that all solvents (if they were used) and trace contaminants have been adequately removed.
- 8. After the equipment has dried, wrap it in aluminum foil for storage until use.

Dredges employed in sediment sampling are typically decontaminated as follows:

- Remove the sediment sample from the sampling device
- If sufficient associated surface water is available at the sampling site, place the dredge in the water and flush to remove visible sediment.
- Extract the dredge and wash it in soap and water per the project-specific planning documents.

CAUTION

When handling dredges, the primary safety concern is trapping fingers or extremities in the larger dredge samplers within the jaws or pinch points of the mechanical jaws. Keep hands, fingers, and extremities away from these pinch and compression points. Either handle the device by the rope or preferably lock the jaws in place to control the potential for closing during maintenance and/or cleaning.

7.3 Contact Waste/Materials

During the course of field investigations, disposable/single-use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.), and broken sample containers.

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With the exception of the broken glass, single-use articles should be cleaned (washed and rinsed) of visible materials and disposed as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned shall be containerized for disposal in accordance with applicable federal, state, and local regulations.

7.3.1 Investigation-Derived Wastes - Decontamination Wash Waters and Sediments

NOTE

Requirements for waste storage may differ from one facility to the next. Facility-specific directions for waste storage areas will be provided in project-specific documents, or separate direction will be provided by the Project Manager.

- Assume that all investigation-derived waste (IDW) generated from decontamination activities contains
 the hazardous chemicals associated with the site unless there are analytical or other data to the
 contrary. Waste solution volumes could vary from a few gallons to several hundred gallons in cases
 where large equipment required cleaning.
- 2. Where possible, use filtering systems to extend the use of water within a closed system wash unit to recycle water and to reduce possible waste amounts.

NOTE

Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility.

- 3. Label waste storage containers appropriately labeled (see Attachment A).
- 4. Ensure that the IDW storage area is configured to meet the following specifications to permit access to the containers and to conduct spill/leak monitoring, sampling, and extraction when the disposal route is determined:
 - Enclose areas accessible by the general public using construction fencing and signs.
 - Stored materials in 55-gallon drums on pallets with four (or fewer) drums per pallet.
 - Maintain the retaining bolt and label on the outside of storage containers where readily visible.
 - Provide at least 4 feet of room between each row of pallets to allow access to containers for sampling, drum removal, and spill response.
 - As directed in project-specific planning documents, maintain an IDW Inventory List and provide the list to the site Point of Contact at the termination of each shift.
 - Maintain spill response equipment at the IDW storage area in case it is required for immediate access.
 - Where possible, use equipment for moving containers. Where not possible, obtain help to manipulate containers.

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CAUTION

Each container of water can weigh up to 490 pounds. Each 55-gallon drum of wet soil can weigh more than 750 pounds. Fill drums and temporary containers to 80 percent capacity to minimize spill and handling difficulties. Use drum carts to move filled drums.

See safe lifting techniques provided in Section 4.4 of the Tetra Tech NUS, Inc. Health and Safety Guidance Manual.

When placing drums, keep your fingers out of pinch and smash points such as between the drums. In some cases such as well development and/or purge water, you can place the drums to be filled on the pallet and transport materials in smaller easier to handle containers.

7.4 <u>Decontamination Evaluation</u>

Upon decontamination of equipment, determine the effectiveness of the decontamination process in the following manner:

- Visual evaluation A visual evaluation will be conducted to ensure the removal of particulate matter.
 This shall be done to ensure that the washing/rinsing process is working as intended.
- Instrument Screening A properly calibrated PID/FID should be used to evaluate the presence of site contaminants and solvents used in the cleaning process. The air intake of the instrument shall be passed over the article to be evaluated. Avoid placing the instrument probe into residual waters. A PID/FID reading greater than the daily established background level requires a repeat of the decontamination process, followed by rescreening with the PID/FID. This sequence must be repeated until no instrument readings greater than the daily established background level are observed. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instrument's capabilities.

NOTE

When required by project-specific planning documents, collection of rinsate blanks (see next step) shall be completed without exception unless approval to not collect these samples is obtained from the Project Manager.

- Collection of Rinsate Blanks It is recommended that rinsate samples be collected to:
 - Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.
 - Single-use disposable equipment The number of samples should represent different types of equipment as well as different lot numbers of single-use articles.
 - The collection and the frequency of collection of rinsate samples are as follows unless specified differently in the project-specific planning documents:
 - Per decontamination method
 - Per disposable article/batch number of disposable articles

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NOTE

It is recommended that an initial rinsate sample be collected early in the project to ensure that the decontamination process is functioning properly and to avoid using a contaminated batch of single-use articles. It is recommended that a follow-up sample be collected later during the execution of the project to ensure that those conditions do not change.

Rinsate samples collection may be driven by types of and/or levels of contaminant. Difficult to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional rinsates due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL.

ANVESTIGATION DERIVED WASTE **GENERATOR INFORMATION:** SITE _____ JOB NO. ____ LOCATION____ DRUM# CONTENTS ____ VOLUME ____ CONTACT _____ EMERGENCY PHONE NUMBER ____

STANDARD OPERATING PROCEDURES DECONTAMINATION OF FIELD EQUIPMENT

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UTILITY LOCATING AND EXCAVATION CLEARANCE

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1.0 PURPOSE

Utilities such as electric service lines, natural or propane gas lines, water and sewage lines, telecommunications, and steam lines are very often in the immediate vicinity of work locations. Contact with underground or overhead utilities can have serious consequences including employee injury/fatality, property and equipment damage, substantial financial impacts, and loss of utility service to users.

The purpose of this procedure is to provide minimum requirements and technical guidelines regarding the appropriate procedures to be followed when performing subsurface and overhead utility locating services. It is the policy of Tetra Tech NUS, Inc. (TtNUS) to provide a safe and healthful work environment for the protection of our employees. The purpose of this Standard Operating Procedure (SOP) is to aid in achieving the objectives of this policy, to present the acceptable procedures pertaining to utility locating and excavation clearance activities, and to present requirements and restrictions relevant to these types of activities. This SOP must be reviewed by any employee potentially involved with underground or overhead utility locating and avoidance activities.

2.0 SCOPE

This procedure applies to all TtNUS field activities where there may be potential contact with underground or overhead utilities. This procedure provides a description of the principles of operation, instrumentation, applicability, and implementability of typical methods used to determine the presence and avoidance of contact with utility services. This procedure is intended to assist with work planning and scheduling, resource planning, field implementation, and subcontractor procurement. Utility locating and excavation clearance requires site-specific information prior to the initiation of any such activities on a specific project. This SOP is not intended to provide a detailed description of methodology and instrument operation. Specialized expertise during both planning and execution of several of the methods presented may also be required.

3.0 GLOSSARY

<u>Electromagnetic Induction (EMI) Survey</u> - A geophysical exploration method whereby electromagnetic fields are induced in the ground and the resultant secondary electromagnetic fields are detected as a measure of ground conductivity.

Magnetometer – A device used for precise and sensitive measurements of magnetic fields.

<u>Magnetic Survey</u> – A geophysical survey method that depends on detection of magnetic anomalies caused by the presence of buried ferromagnetic objects.

<u>Metal Detection</u> – A geophysical survey method that is based on electromagnetic coupling caused by underground conductive objects.

<u>Vertical Gradiometer</u> – A magnetometer equipped with two sensors that are vertically separated by a fixed distance. It is best suited to map near surface features and is less susceptible to deep geologic features.

<u>Ground Penetrating Radar</u> – Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture.

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4.0 RESPONSIBILITIES

<u>Project Manager (PM)/Task Order Manager (TOM)</u> - Responsible for ensuring that all field activities are conducted in accordance with this procedure.

<u>Site Manager (SM)/Field Operations Leader (FOL)</u> - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

<u>Site Health & Safety Officer (SHSO)</u> – Responsible to provide technical assistance and verify full compliance with this SOP. The SHSO is also responsible for reporting any deficiencies to the Corporate Health and Safety Manager (HSM) and to the PM/TOM.

<u>Health & Safety Manager (HSM)</u> – Responsible for preparing, implementing, and modifying corporate health and safety policy and this SOP.

<u>Site Personnel</u> – Responsible for performing their work activities in accordance with this SOP and the TtNUS Health and Safety Policy.

5.0 PROCEDURES

This procedure addresses the requirements and technical procedures that must be performed to minimize the potential for contact with underground and overhead utility services. These procedures are addressed individually from a buried and overhead standpoint.

5.1 Buried Utilities

Buried utilities present a heightened concern because their location is not typically obvious by visual observation, and it is common that their presence and/or location is unknown or incorrectly known on client properties. This procedure must be followed prior to beginning any subsurface probing or excavation that might potentially be in the vicinity of underground utility services. In addition, the Utility Clearance Form (Attachment 3) must be completed for every location or cluster of locations where intrusive activities will occur.

Where the positive identification and de-energizing of underground utilities cannot be obtained and confirmed using the following steps, the PM/TOM is responsible for arranging for the procurement of a qualified, experienced, utility locating subcontractor who will accomplish the utility location and demarcation duties specified herein.

- A comprehensive review must be made of any available property maps, blue lines, or as-builts
 prior to site activities. Interviews with local personnel familiar with the area should be performed
 to provide additional information concerning the location of potential underground utilities.
 Information regarding utility locations shall be added to project maps upon completion of this
 exercise.
- 2., A visual site inspection must be performed to compare the site plan information to actual field conditions. Any findings must be documented and the site plan/maps revised. The area(s) of proposed excavation or other subsurface activities must be marked at the site in white paint or pin flags to identify those locations of the proposed intrusive activities. The site inspection should focus on locating surface indications of potential underground utilities. Items of interest include the presence of nearby area lights, telephone service, drainage grates, fire hydrants, electrical service vaults/panels, asphalt/concrete scares and patches, and topographical depressions. Note the location of any emergency shut off switches. Any additional information regarding utility

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locations shall be added to project maps upon completion of this exercise and returned to the PM/TOM.

- 3. If the planned work is to be conducted on private property (e.g., military installations, manufacturing facilities, etc.) the FOL must identify and contact appropriate facility personnel (e.g., public works or facility engineering) before any intrusive work begins to inquire about (and comply with) property owner requirements. It is important to note that private property owners may require several days to several weeks advance notice prior to locating utilities.
- 4. If the work location is on public property, the state agency that performs utility clearances must be notified (see Attachment 1). State "one-call" services must be notified prior to commencing fieldwork per their requirements. Most one-call services require, by law, 48- to 72-hour advance notice prior to beginning any excavation. Such services typically assign a "ticket" number to the particular site. This ticket number must be recorded for future reference and is valid for a specific period of time, but may be extended by contacting the service again. The utility service will notify utility representatives who then mark their respective lines within the specified time frame. It should be noted that most military installations own their own utilities but may lease service and maintenance from area providers. Given this situation, "one call" systems may still be required to provide location services on military installations.
- 5. Utilities must be identified and their locations plainly marked using pin flags, spray paint, or other accepted means. The location of all utilities must be noted on a field sketch for future inclusion on project maps. Utility locations are to be identified using the following industry-standard color code scheme, unless the property owner or utility locator service uses a different color code:

white excavation/subsurface investigation location red electrical yellow gas, oil, steam orange telephone, communications blue water, irrigation, slurry green sewer, drain

- 6. Where utility locations are not confirmed with a high degree of confidence through drawings, schematics, location services, etc., the work area must be thoroughly investigated prior to beginning the excavation. In these situations, utilities must be identified using safe and effective methods such as passive and intrusive surveys, or the use of non-conductive hand tools. Also, in situations where such hand tools are used, they should always be used in conjunction with suitable detection equipment, such as the items described in Section 6.0 of this SOP. Each method has advantages and disadvantages including complexity, applicability, and price. It also should be noted that in some states, initial excavation is required by hand to a specified depth.
- At each location where trenching or excavating will occur using a backhoe or other heavy equipment, and where utility identifications and locations cannot be confirmed prior to groundbreaking, the soil must be probed using a device such as a tile probe which is made of non-conductive material such as fiberglass. If these efforts are not successful in clearing the excavation area of suspect utilities, hand shoveling must be performed for the perimeter of the intended excavation.
- 8. All utilities uncovered or undermined during excavation must be structurally supported to prevent potential damage. Unless necessary as an emergency corrective measure, TtNUS shall not make any repairs or modifications to existing utility lines without prior permission of the utility owner, property owner, and Corporate HSM. All repairs require that the line be locked-out/tagged-out prior to work.

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5.2 Overhead Power Lines

If it is necessary to work within the minimum clearance distance of an overhead power line, the overhead line must be de-energized and grounded, or re-routed by the utility company or a registered electrician. If protective measures such as guarding, isolating, or insulating are provided, these precautions must be adequate to prevent employees from contacting such lines directly with any part of their body or indirectly though conductive materials, tools, or equipment.

The following table provides the required minimum clearances for working in proximity to overhead power lines

Nominal Voltage 0 -50 kV	Minimum Clearance 10 feet, or one mast length; whichever is greater
50+ kV	10 feet plus 4 inches for every 10 kV over 50 kV or 1.5 mast lengths; whichever is greater

6.0 UNDERGROUND LOCATING TECHNIQUES

A variety of supplemental utility locating approaches are available and can be applied when additional assurance is needed. The selection of the appropriate method(s) to employ is site-specific and should be tailored to the anticipated conditions, site and project constraints, and personnel capabilities.

6.1 Geophysical Methods

Geophysical methods include electromagnetic induction, magnetics, and ground penetrating radar. Additional details concerning the design and implementation of electromagnetic induction, magnetics, and ground penetrating radar surveys can be found in one or more of the TtNUS SOPs included in the References (Section 8.0).

Electromagnetic Induction

Electromagnetic Induction (EMI) line locators operate either by locating a background signal or by locating a signal introduced into the utility line using a transmitter. A utility line acts like a radio antenna, producing electrons, which can be picked up with a radiofrequency receiver. Electrical current carrying conductors have a 60HZ signal associated with them. This signal occurs in all power lines regardless of voltage. Utilities in close proximity to power lines or used as grounds may also have a 60HZ signal, which can be picked up with an EM receiver. A typical example of this type of geophysical equipment is an EM-61.

EMI locators specifically designed for utility locating use a special signal that is either indirectly induced onto a utility line by placing the transmitter above the line or directly induced using an induction clamp. The clamp induces a signal on the specific utility and is the preferred method of tracing since there is little chance of the resulting signals being interfered with. A good example of this type of equipment is the Schonstedt® MAC-51B locator. The MAC-51B performs inductively traced surveys, simple magnetic locating, and traced nonmetallic surveys.

When access can be gained inside a conduit to be traced, a flexible insulated trace wire can be used. This is very useful for non-metallic conduits but is limited by the availability of gaining access inside the pipe.

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Magnetics

Magnetic locators operate by detecting the relative amounts of buried ferrous metal. They are incapable of locating or identifying nonferrous utility lines but can be very useful for locating underground storage tanks (UST's), steel utility lines, and buried electrical lines. A typical example of this type of equipment is the Schonstedt® GA-52Cx locator. The GA-52Cx is capable of locating 4-inch steel pipe up to 8 feet deep.

Non-ferrous lines are often located by using a typical plumbing tool (snake) fed through the line. A signal is then introduced to the snake that is then traced.

Ground Penetrating Radar

Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture. In general, an object which is harder than the surrounding soil will reflect a stronger signal. Utilities, tunnels, UST's, and footings will reflect a stronger signal than the surrounding soil. Although this surface detection method may determine the location of a utility, this method does not specifically identify utilities (i.e., water vs. gas, electrical vs. telephone); hence, verification may be necessary using other methods. This method is somewhat limited when used in areas with clay soil types or with a high water table.

6.2 <u>Passive Detection Surveys</u>

Acoustic Surveys

Acoustic location methods are generally most applicable to waterlines or gas lines. A highly sensitive Acoustic Receiver listens for background sounds of water flowing (at joints, leaks, etc.) or to sounds introduced into the water main using a transducer. Acoustics may also be applicable to determine the location of plastic gas lines.

Thermal Imaging

Thermal (i.e., infrared) imaging is a passive method for detecting the heat emitted by an object. Electronics in the infrared camera convert subtle heat differentials into a visual image on the viewfinder or a monitor. The operator does not look for an exact temperature; rather they look for heat anomalies (either elevated or suppressed temperatures) characteristic of a potential utility line.

The thermal fingerprint of underground utilities results from differences in temperature between the atmosphere and the fluid present in a pipe or the heat generated by electrical resistance. In addition, infrared scanners may be capable of detecting differences in the compaction, temperature and moisture content of underground utility trenches. High-performance thermal imagery can detect temperature differences to hundredths of a degree.

6.3 Intrusive Detection Surveys

Vacuum Excavation

Vacuum excavation is used to physically expose utility services. The process involves removing the surface material over approximately a 1' x 1' area at the site location. The air-vacuum process proceeds with the simultaneous action of compressed air-jets to loosen soil and vacuum extraction of the resulting

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debris. This process ensures the integrity of the utility line during the excavation process, as no hammers, blades, or heavy mechanical equipment comes into contact with the utility line, eliminating the risk of damage to utilities. The process continues until the utility is uncovered. Vacuum excavation can be used at the proposed site location to excavate below the "utility window" which is usually 8 feet.

Hand Excavation

When the identification and location of underground utilities cannot be positively confirmed through document reviews and/or other methods, borings and excavations may be cleared via the use of non-conductive hand tools. This should always be done in conjunction with the use of detection equipment. This would be required for all locations where there is a potential to impact buried utilities. The minimum hand-excavation depth that must be reached is to be determined considering the geographical location of the work site. This approach recognizes that the placement of buried utilities is influenced by frost line depths that vary by geographical region. Attachment 2 presents frost line depths for the regions of the contiguous United States. At a minimum, hand excavation depths must be at least to the frost line depth (see Attachment 2) plus two (2) feet, but never less than 4 feet below ground surface (bgs). For hand excavation, the hole created must be reamed large enough to be at least the diameter of the drill rig auger or bit prior to drilling. For soil gas surveys, the survey probe shall be placed as close as possible to the cleared hand excavation. It is important to note that a post-hole digger must not be used in this type of hand excavation activity.

Tile Probe Surveys

For some soil types, site conditions, and excavation requirements, non-conductive tile probes may be used. A tile probe is a "T"-handled rod of varying lengths that can be pushed into the soil to determine if any obstructions exist at that location. Tile probes constructed of fiberglass or other nonconductive material are readily-available from numerous vendors. Tile probes must be performed to the same depth requirements as previously specified. As with other types of hand excavating activities, the use of a nonconductive tile probe, should always be in conjunction with suitable utility locating detection equipment.

7.0 INTRUSIVE ACTIVITIES SUMMARY

The following list summarizes the activities that must be performed prior to beginning subsurface activities:

- 1. Map and mark all subsurface locations and excavation boundaries using white paint or markers specified by the client or property owner.
- 2. Notify the property owner and/or client that the locations are marked. At this point, drawings of locations or excavation boundaries shall be provided to the property owner and/or client so they may initiate (if applicable) utility clearance.
 - Note: Drawings with confirmed locations should be provided to the property owner and/or client as soon as possible to reduce potential time delays.
- 3. Notify "One Call" service. If possible, arrange for an appointment to show the One Call representative the surface locations or excavation boundaries in person. This will provide a better location designation to the utilities they represent. You should have additional drawings should you need to provide plot plans to the One Call service.
- 4. Implement supplemental utility detection techniques as necessary and appropriate to conform utility locations or the absence thereof.

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5. Complete Attachment 3, Utility Clearance Form. This form should be completed for each excavation location. In situations where multiple subsurface locations exist within the close proximity of one another, one form may be used for multiple locations provided those locations are noted on the Utility Clearance Form. Upon completion, the Utility Clearance Form and revised/annotated utility location map becomes part of the project file.

8.0 REFERENCES

OSHA Letter of Interpretation, Mr. Joseph Caldwell, Attachment 4 OSHA 29 CFR 1926(b)(2)

OSHA 29 CFR 1926(b)(3)

TtNUS Utility Locating and Clearance Policy

TtNUS SOP GH-3.1; Resistivity and Electromagnetic Induction

TtNUS SOP GH-3.2; Magnetic and Metal Detection Surveys

TtNUS SOP GH-3.4; Ground-penetrating Radar Surveys

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ATTACHMENT 1 LISTING OF UNDERGROUND UTILITY CLEARANCE RESOURCES



American Public Works Association 2345 Grand Boulevard, Suite 500, Kansas City, MO 64108-2625 Phone (816) 472-6100 • Fax (816) 472-1610 Web www.apwa.net • E-mail apwa@apwa.net

ONE-CALL SYSTEMS INTERNATIONAL CONDENSED DIRECTORY

Alabama Alabama One-Call 1-800-292-8525

Alaska Locate Call Center of Alaska, Inc. 1-800-478-3121

Arizona Arizona Blue Stake 1-800-782-5348

Arkansas Arkansas One Call System, Inc. 1-800-482-8998

California
Underground Service Alert North
1-800-227-2600
Underground Service Alert of Southern
California
1-800-227-2600

Colorado
Utility Notification Center of Colorado
1-800-922-1987

Connecticut Call Before You Dig 1-800-922-4455

Delaware Miss Utility of Delmarva 1-800-282-8555

Florida Sunshine State One-Call of Florida, Inc. 1-800-432-4770

Georgia Underground Protection Center, Inc. 1-800-282-7411

Hawaii Underground Service Alert North 1-800-227-2600

idaho Dig Line Inc. 1-800-342-1585 Kootenal County One-Call 1-800-428-4950 Shoshone - Benewah One-Call 1-800-398-3285

Illinois
JULIE, Inc.
1-800-892-0123
Digger (Chicago Utility Alert Network)
312-744-7000

Indiana Indiana Underground Plant Protection Service 1-800-382-5544 lowa One-Call 1-800-292-8989

Kansas One-Call System, Inc. 1-800-344-7233

Kentucky Kentucky Underground Protection Inc. 1-800-752-8007

Louisiana Louisiana One Call System, Inc. 1-800-272-3020

Maine Dig Safe System, Inc. 1-888-344-7233

Maryland Miss Utility 1-800-257-7777 Miss Utility of Delmarva 1-800-282-8555

Massachusetts
Dig Safe System, Inc.
1-888-344-7233

Michigan Miss Dig System, Inc. 1-800-482-7171

Minnesota Gopher State One Call 1-800-252-1166

Mississippi Mississippi One-Call System, Inc 1-800-227-6477

Missouri Missouri One-Call System, Inc. 1-800-344-7483

Montana Utilities Underground Protection Center 1-800-424-5555 Montana One Call Center 1-800-551-8344

Nebraska Diggers Hotline of Nebraska 1-800-331-5666

Nevada Underground Service Alert North 1-800-227-2600

New Hampshire Dig Safe System, Inc. 1-888-344-7233 New Jersey New Jersey One Call 1-800-272-1000

New Mexico New Mexico One Call System, Inc. 1-800-321-2537 Las Cruces- Dona Ana Blue Stakes 1-888-526-0400

New York
Dig Safety New York
1-800-962-7952
New York City- Long Island One Call
Center
1-800-272-4480

North Carolina
The North Carolina One-Call Center,
Inc.
1-800-632-4949

North Dakota North Dakota One-Call 1-800-795-0555

Ohio
Ohio Utilities Protection Servics
1-800-362-2764
Oil & Gas Producers Underground
Protect'n Svc
1-800-925-0988

Okiahoma Call Okie 1-800-522-6543

Oregon
Oregon Utility Notification Center/One
Call Concepts
1-800-332-2344

Pennsylvania Pennsylvania One Cali System, Inc. 1-800-242-1776

Rhode Island Dig Safe System, Inc. 1-888-344-7233

South Carolina
Palmetto Utility Protection Service Inc.
1-888-721-7877

South Dakota South Dakota One Call 1-800-781-7474

Tennessee Tennessee One-Call System, Inc. 1-800-351-1111

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ATTACHMENT 1 (Continued)

Texas
Texas One Call System
1-800-245-4545
Texas Excavation Safety System, Inc.
1-800-344-8377
Lone Star Notification Center
1-800-669-8344

Utah Blue Stakes of Utah 1-800-662-4111

Vermont Dig Safe System, Inc. 1-888-344-7233

Virginia Miss Utility of Virginia 1-800-552-7001 Miss Utility (Northern Virginia) 1-800-257-7777 Washington
Utilities Underground Location Center
1-800-424-5555
Northwest Utility Notification Center
1-800-553-4344
Inland Empire Utility Coordinating
Council
509-456-8000

West Virginia Miss Utility of West Virginia, Inc. 1-800-245-4848

Wisconsin Diggers Hotline, Inc. 1-800-242-8511

Wyoming Wyoming One-Call System, Inc. 1-800-348-1030 Call Before You Dig of Wyoming 1-800-849-2476 District of Columbia Miss Utility 1-800-257-7777

Alberta Alberta One-Call Corporation 1-800-242-3447

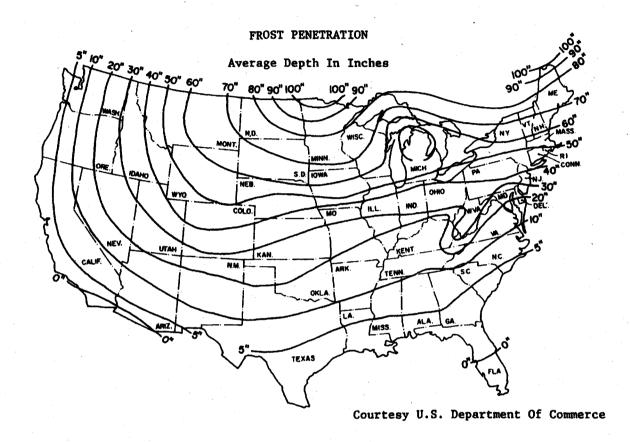
British Columbia BC One Call 1-800-474-6886

Ontario One-Call System 1-800-400-2255

Quebec Info-Excavation 1-800-663-9228

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ATTACHMENT 2 FROST LINE PENETRATION DEPTHS BY GEOGRAPHIC LOCATION



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ATTACHMENT 3 UTILITY CLEARANCE FORM

		Completed By:			
		: Work Date:			
		thod/Overhead Equipment:			
. \	Jnderg	round Utilities		cle O	-
a	a)	Review of existing maps?	yes	no	N/A
b	o)	Interview local personnel?	yes	no	N/A
C	c)	Site visit and inspection?	yes	no	N/A
d	d)	Excavation areas marked in the field?	yes	no	N/A
е	∋)	Utilities located in the field?	yes	no	N/A
f	")	Located utilities marked/added to site maps?	yes	no	N/A
g	3)	Client contact notified		no	N/A
		Name Telephone: Date:			
g	g)	State One-Call agency called?	yes	no	N/A
		Caller: Date:			
h	i)	Geophysical survey performed?		no	N/A
	,	Survey performed by: Method: Date:			
;;	`	Hand excavation performed (with concurrent use of utility		no	N/A
i))	detection device)?	yes	110	14/7
		Completed by: Total depth:feet Date:			
.,					NI/A
j)) .	Trench/excavation probed? Probing completed by:	yes	no	N/A
		Depth/frequency: Date:			
C	Overhe	ead Utilities	Pre	sent	Abse
	a)	Determination of nominal voltage			N/A
	o)	Marked on site maps Necessary to lockout/insulate/re-route			N/A N/A
	c) d)	Document procedures used to lockout/insulate/re-route			N/A
	∍)	Minimum acceptable clearance (SOP Section 5.2):			
. 1	Notes:				
-			· · · · · · · · · · · · · · · · · · ·		
_					
F	Approv	al:			
7	Site Ma	anager/Field Operations Leader Date			

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ATTACHMENT 4 OSHA LETTER OF INTERPRETATION

Mr. Joseph Caldwell Consultant Governmental Liaison Pipeline Safety Regulations 211 Wilson Boulevard Suite 700 Arlington, Virginia 22201

Re: Use of hydro-vacuum or non-conductive hand tools to locate underground utilities.

Dear Mr. Caldwell:

In a letter dated July 7, 2003, we responded to your inquiry of September 18, 2002, regarding the use of hydro-vacuum equipment to locate underground utilities by excavation. After our letter to you was posted on the OSHA website, we received numerous inquiries that make it apparent that aspects of our July 7 letter are being misunderstood. In addition, a number of industry stakeholders, including the National Utility Contractors Association (NUCA), have provided new information regarding equipment that is available for this work.

To clarify these issues, we are withdrawing our July 7 letter and issuing this replacement response to your inquiry.

Question: Section 1926.651 contains several requirements that relate to the safety of employees engaged in excavation work. Specifically, paragraphs (b)(2) and (b)(3) relate in part to the safety of the means used to locate underground utility installations that, if damaged during an uncovering operation, could pose serious hazards to employees.

Under these provisions, what constitutes an acceptable method of uncovering underground utility lines, and further, would the use of hydro-vacuum excavation be acceptable under the standard?

Answer

Background

Two sections of 29 CFR 1926 Subpart P (Excavations), 1926.651(Specific excavation requirements), govern methods for uncovering underground utility installations. Specifically, paragraph (b)(2) states:

When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours * * * or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used. (emphasis added).

Paragraph (b)(3) provides:

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ATTACHMENT 4 (Continued)

When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by <u>safe and acceptable means</u>. (emphasis added).

Therefore, "acceptable means" must be used where the location of the underground utilities have not been identified by the utility companies and detection equipment is not used.

Subpart P does not contain a definition of either "other acceptable means" or "safe and acceptable means." The preambles to both the proposed rule and the final rule discussed the rationale behind the wording at issue. For example, the preamble to the proposed rule, 52 Fed. Reg. 12301 (April 15, 1987), noted that a 1972 version of this standard contained language that specified "careful probing or hand digging" as the means to uncover utilities. The preamble then noted that an amendment to the 1972 standard later deleted that language "to allow other, equally effective means of locating such installations." The preamble continued that in the 1987 proposed rule, OSHA again proposed using language in section (b)(3) that would provide another example of an acceptable method of uncovering utilities that could be used where the utilities have not been marked and detection equipment is not being used — "probing with hand-held tools." This method was rejected in the final version of 29 CFR 1926. As OSHA explained in the preamble to the final rule, 54 Fed. Reg. 45916 (October 31, 1989):

OSHA received two comments * * * and input from ACCSH [OSHA's Advisory Committee on Construction Safety and Health] * * * on this provision. All commenters recommended dropping 'such as probing with hand-held tools' from the proposed provision, because this could create a hazard to employees by damaging the installation or its insulation.

In other words, the commenters objected to the use of hand tools being used unless detection equipment was used in conjunction with them. OSHA then concluded its discussion relative to this provision by agreeing with the commentators and ultimately not including any examples of "acceptable means" in the final provision.

Non-conductive hand tools are permitted

This raises the question of whether the standard permits the use of hand tools alone -- without also using detection equipment. NUCA and other industry stakeholders have recently informed us that non-conductive hand tools that are appropriate to be used to locate underground utilities are now commonly available.

Such tools, such as a "shooter" (which has a non-conductive handle and a snub nose) and non-conductive or insulated probes were not discussed in the rulemaking. Since they were not considered at that time, they were not part of the class of equipment that was thought to be unsafe for this purpose. Therefore, we conclude that the use of these types of hand tools, when used with appropriate caution, is an "acceptable means" for locating underground utilities.

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ATTACHMENT 4 (Continued)

Hydro-vacuum excavation

It is our understanding that some hydro-vacuum excavation equipment can be adjusted to use a minimum amount of water and suction pressure. When appropriately adjusted so that the equipment will not damage underground utilities (especially utilities that are particularly vulnerable to damage, such as electrical lines), use of such equipment would be considered a "acceptable means" of locating underground utilities. However, if the equipment cannot be sufficiently adjusted, then this method would not be acceptable under the standard.

Other technologies

We are not suggesting that these are the only devices that would be "acceptable means" under the standard. Industry stakeholders have informed us that there are other types of special excavation equipment designed for safely locating utilities as well.

We apologize for any confusion our July 7 letter may have caused. If you have further concerns or questions, please feel free to contact us again by fax at: U.S. Department of Labor, OSHA, Directorate of Construction, Office of Construction Standards and Compliance Assistance, fax # 202-693-1689. You can also contact us by mail at the above office, Room N3468, 200 Constitution Avenue, N.W., Washington, D.C. 20210, although there will be a delay in our receiving correspondence by mail.

Sincerely,

Russell B. Swanson, Director Directorate of Construction

NOTE: OSHA requirements are set by statute, standards and regulations. Our interpretation letters explain these requirements and how they apply to particular circumstances, but they cannot create additional employer obligations. This letter constitutes OSHA=s interpretation of the requirements discussed. Note that our enforcement guidance may be affected by changes to OSHA rules. Also, from time to time we update our guidance in response to new information. To keep apprised of such developments, you can consult OSHA's website at http://www.osha.gov.

030807/P (Appendix D) CTO 447

FIELD TASK MODIFICATION REQUEST FORM

- Alfred Haling St	CTO a Decision N	The Laboratory of the Control of the
roject/Installation Name	CTO & Project Number	Task Mod. Number
f lift at m (- What the)	O'A IO	
Modification To (e.g. Work Plan)	Site/Sample Location	Date
athit. Decide		
Activity Description:		
	<u></u>	
Reason for Change:		
Recommended Disposition:	· · · · · · · · · · · · · · · · · · ·	
ield Operations Leader (Signature	<u> </u>	Date
reid Operations Deader (Dignature	" "	Daw
Approved Disposition:		
approved Disposition.		
*		
Project/Task Order Manager (Sign	ature)	Date
Distribution:		
Program/Project File –	Other:	
Project/Task Order Manager -		
ield Operations Leader –		
	•	

Appendix C Laboratory DoD ELAP Certifications



Accredited Laboratory

A2LA has accredited

ALS-MIDDLETOWN

Middletown, PA

for technical competence in the field of

Environmental Testing

In recognition of the successful completion of the A2LA evaluation process that includes an assessment of the laboratory's compliance with ISO/IEC 17025:2005, the 2009 TNI Standard, and the requirements of the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.0 of the DoD Quality System Manual for Environmental Laboratories (QSM), accreditation is granted to this laboratory to perform recognized EPA methods as defined on the associated A2LA Environmental Scope of Accreditation. This accreditation demonstrates technical competence for this defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).



Presented this 28th day of December 2015.

President & CEO

For the Accreditation Council Certificate Number 0818.01

Valid To November 30, 2017



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

ALS – MIDDLETOWN
34 Dogwood Lane
Middletown, PA 17057
Susan Magness Phone: 717 944 5541

ENVIRONMENTAL

Valid To: November 30, 2017 Certificate Number: 0818.01

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2009 TNI Standard, and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.0 of the DoD Quality Systems Manual for Environmental Laboratories) accreditation is granted to this laboratory to perform recognized EPA methods using the following testing technologies and in the analyte categories identified below:

Testing Technologies

Inductively Coupled Plasma (ICP), ICP-Mass Spectroscopy, Atomic Absorption Spectroscopy (flame), Gas Chromatography(GC), GC- Mass Spectroscopy, High Resolution Gas Chromatography/High Resolution Mass Spectroscopy, Liquid Chromatography(LC), LC- Mass Spectroscopy, Ion Chromatography, TCLP, SPLP, Spectrophotometry, Misc.- Electronic Probes

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste	Air	Associated Prep
Microwave Acid Digestion for		<u>Soil</u>		Methods EPA 3015A/3051A
Metals				
Hotplate Metals Digestion				EPA 3050B
Organics Extraction - General	****************		********	EPA 3500B
Sep Funnel Liq-Liq Extraction		wir dat dat das son des mit dat die die die der dat der der der der der dat for dat der son mit son om om		EPA 3510C
Solid Phase Extraction				EPA 3535
Microwave Organic Extraction				EPA 3546
Soils				100
Sonication Organic Soil				EPA 3550B
Extraction				
Florisil Clean-Up Organics				EPA 3620B
Sulfur Clean-Up PCB's				EPA 3660B
Sulfuric Acid PCBs		***************************************		EPA 3665A
VOC Soils				EPA 5035A
Alkalinity	SM 2320B			
Ammonia	ASTM D6919-09			
Biochemical Oxygen Demand	SM 5210B			
(BOD)				
Carbonaceous BOD (CBOD)	SM 5210B			

Peter Mhyen

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
Chemical Oxygen Demand (COD)	EPA 410.4 HACH 8000			
Total Cyanide	EPA 9012B	EPA 9012B		
Reactive Cyanide	EPA 7.3.3.2/9012B	EPA 7.3.3.2/9012B		
Ferrous Iron	SM3500			
Hexane Extractable Materials	EPA 1664B	EPA 9071B		
(HEM)				
Hexavalent Chromium	EPA 7196A	EPA 7196A		
MBAS (Surfactants)	EPA 5540C			
Total Kjeldahl Nitrogen (TKN)	SM 4500 NH3G			SM 4500 Norg B+C
pH, Corrosivity, Hydrogen Ion	EPA 9040B/9040C	EPA 9045D		
Phenolic Substances	EPA 9066	EPA 9066		
Bromide	EPA 300.0	EPA 300.0		
	EPA 9056A	EPA 9056A		
Chloride	EPA 300.0	EPA 300.0		
	EPA 9056A	EPA 9056A		
Fluoride	EPA 300.0	EPA 300.0		
	EPA 9056A	EPA 9056A		
Nitrate	EPA 300.0	EPA 300.0		
	EPA 9056A	EPA 9056A		
Nitrite	EPA 300.0	EPA 300.0		
	EPA 9056A	EPA 9056A		
Sulfate	EPA 300.0	EPA 300.0		
Surface	EPA 9056A	EPA 9056A		
Specific Conductance	EPA 120.1			
Specific Conductance	EPA 9050A			
Sulfide	SM4500-S2F			
Reactive Sulfide	SW846 7.3.4.2	SW846 7.3.4.2		
Perchlorate	EPA 314.0			
Total Organic Carbon	EPA 9060A			
Total Organic Carbon	SM5310B-2000			
Total Organic Halides	EPA 9020B	EPA 9023		
Total Dissolved Solids	SM 2540C	LIN 7023		
Total Solids	51VI 2540C	SM2540G-1997	+	
	EDA COLOC			
Aluminum	EPA 6010C	EPA 6010C		
	EPA 6020A	EPA 6020A		
Antimony	EPA 6010C	EPA 6010C	4	
	EPA 6020A	EPA 6020A	-	
Arsenic	EPA 6010C	EPA 6010C		
	EPA 6020A	EPA 6020A		
Barium	EPA 6010C	EPA 6010C		
	EPA 6020A	EPA 6020A		
Beryllium	EPA 6010C	EPA 6010C		
	EPA 6020A	EPA 6020A		
Bismuth	EPA 6010C	EPA 6010C		
Boron	EPA 6010C	EPA 6010C		
Cadmium	EPA 6010C	EPA 6010C		
	EPA 6020A	EPA 6020A		
Calcium	EPA 6010C	EPA 6010C		
	EPA 6020A	EPA 6020A		
Calcium Hardness (CaCO3)	EPA 6010C	EPA 6010C		
Catorain Haraness (CaCOS)	Littorioc	DITT OUTO		

Peter Mhyse Page 2 of 13

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste	Air	Associated Prep
· ··· · ·—		Soil		Methods
Chromium	EPA 6010C	EPA 6010C		
	EPA 6020A	EPA 6020A		
Cobalt	EPA 6010C	EPA 6010C		
	EPA 6020A	EPA 6020A		
Copper	EPA 6010C	EPA 6010C		
••	EPA 6020A	EPA 6020A		
Hardness-Total as CaCO3	EPA 6010C	EPA 6010C		
Iron	EPA 6010C	EPA 6010C		
	EPA 6020A	EPA 6020A		
Lead	EPA 6010C	EPA 6020A		
	EPA 6020A			
Lithium	EPA 6010C	EPA 6010C		
	EPA 6020A	EPA 6020A		
Magnesium	EPA 6010C	EPA 6010C		
<i>G</i>	EPA 6020A	EPA 6020A		
Manganese	EPA 6010C	EPA 6010C		
	EPA 6020A	EPA 6020A		
Mercury	EPA 6020A	EPA 6020A		*********
1.10.00.1	EPA 7470A	EPA 7471B		
	EPA 1631			
Molybdenum	EPA 6010C	EPA 6010C		
ory oddinam	EPA 6020A	EPA 6020A		
Nickel	EPA 6010C	EPA 6010C		
HIGHOI	EPA 6020A	EPA 6020A		
Potassium	EPA 6010C	EPA 6010C		
1 Otassium	EPA 6020A	EPA 6020A		
Selenium	EPA 6010C	EPA 6010C		
Scientini	EPA 6020A	EPA 6020A		
Silica as SiO2	EPA 6010C	EPA 6010C		
Silica as SiO2	EPA 6020A	EPA 6020A		
Silver	EPA 6010C	EPA 6010C		<u> </u>
Silver	EPA 6020A	EPA 6020A		
Sodium	EPA 6010C	EPA 6010C		
Sodium	EPA 6020A	EPA 6020A		
Strontium	EPA 6010C	EPA 6010C		
Strontium	EPA 6020A	EPA 6020A		
Sulfur	EPA 6010C	EPA 6010C		
Sullur	EPA 6020A	EPA 6020A		
Thallium	EPA 6010C	EPA 6010C		
Thamum	EPA 6020A	EPA 6020A		
Tim				
Tin	EPA 6010C	EPA 6010C		
em.	EPA 6020A	EPA 6020A		
Titanium	EPA 6010C	EPA 6010C		
* 7 1'	EPA 6020A	EPA 6020A	1	
Vanadium	EPA 6010C	EPA 6010C		
	EPA 6020A	EPA 6020A		
Zinc	EPA 6010C	EPA 6010C		
	EPA 6020A	EPA 6020A	1	
Ethanol	EPA 8015C			
Ethyl Acetate	EPA 8015C			
Ethylene Glycol	EPA 8015C			

Peter Mhyer Page 3 of 13

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
Isoamyl Alcohol	EPA 8015C			
Isobutyl Alcohol (2 methyl-1- propanol)	EPA 8015C			
Isopropyl Alcohol (2-propanol) (Isopropanol)	EPA 8015C			
Methanol	EPA 8015C			
Methyl Ethyl Ketone (2-	EPA 8015C			
butanone)				
Methyl Isobutyl Ketone (MIBK)	EPA 8015C			
n-Butanol	EPA 8015C			
n-Propanol	EPA 8015C			
Propylene Glycol	EPA 8015C			
tert-Butyl Alcohol	EPA 8015C			
TPH Diesel (DRO)	EPA 8015D	EPA 8015D		
TPH Gasoline (GRO)	EPA 8015D	EPA 8015D		
4,4'-DDD	EPA 8081B	EPA 8081B		
4,4'-DDE	EPA 8081B	EPA 8081B		
4,4'-DDT	EPA 8081B	EPA 8081B		
Aldrin (HHDN)	EPA 8081B	EPA 8081B		
Chlordane (tech.)	EPA 8081B	EPA 8081B		
Dieldrin	EPA 8081B	EPA 8081B		
Endosulfan I	EPA 8081B	EPA 8081B		
Endosulfan II	EPA 8081B	EPA 8081B		
Endosulfan Sulfate	EPA 8081B	EPA 8081B		
Endrin	EPA 8081B	EPA 8081B		
Endrin Aldehyde	EPA 8081B	EPA 8081B		
Endrin Ketone	EPA 8081B	EPA 8081B		
Heptachlor	EPA 8081B	EPA 8081B		
Heptachlor Epoxide	EPA 8081B	EPA 8081B		
Methoxychlor	EPA 8081B	EPA 8081B		
Mirex	EPA 8081B	EPA 8081B		
Toxaphene (Chlorinated	EPA 8081B	EPA 8081B		
Camphene) alpha-BHC	EPA 8081B	EPA 8081B	_	
alpha-Chlordane	EPA 8081B	EPA 8081B		
beta-BHC	EPA 8081B	EPA 8081B		
delta-BHC	EPA 8081B	EPA 8081B		
gamma-BHC (Lindane)	EPA 8081B	EPA 8081B		
gamma-Chlordane	EPA 8081B	EPA 8081B		
Aroclor-1016 (PCB-1016)	EPA 8082A	EPA 8082A		-
Aroclor-1221 (PCB-1221)	EPA 8082A	EPA 8082A		
Aroclor-1221 (PCB-1221) Aroclor-1232 (PCB-1232)		EPA 8082A		
Aroclor-1242 (PCB-1242)	EPA 8082A	 		
Aroclor-1242 (PCB-1242) Aroclor-1248 (PCB-1248)	EPA 8082A EPA 8082A	EPA 8082A EPA 8082A		
		EPA 8082A		
Aroclor-1254 (PCB-1254)	EPA 8082A	+		
Aroclor-1260 (PCB-1260)	EPA 8082A	EPA 8082A		
Acetochlor	EPA 8141B	EPA 8141B		
Alachlor	EPA 8141B	EPA 8141B		
Atrazine	EPA 8141B	EPA 8141B		
Azinphos Methyl		EPA 8141B		

Peter Mbryer

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
Bolstar		EPA 8141B		***************************************
Bromacil	EPA 8141B	EPA 8141B		
Butachlor	EPA 8141B	EPA 8141B		
Chlorpyrifos	EPA 8141B	EPA 8141B		
Coumaphos		EPA 8141B		
Cyanazine	EPA 8141B	EPA 8141B		
Demeton-O		EPA 8141B		
Demeton- S		EPA 8141B		
Diazinon	440444111111111111111111111111111111111	EPA 8141B		
Dichlorvos		EPA 8141B		
Ethoprop		EPA 8141B		
Fensulfothion		EPA 8141B		
Fenthion		EPA 8141B		
Malathion		EPA 8141B		
Metolachlor	EPA 8141B	EPA 8141B		
Metribuzin	EPA 8141B	EPA 8141B		
Mevinphos		EPA 8141B		
Molinate	EPA 8141B	EPA 8141B		
Parathion Ethyl		EPA 8141B		
Parathion Methyl		EPA 8141B		
Pendimethalin (Penoxalin)	EPA 8141B	EPA 8141B		
Phorate		EPA 8141B		
Prometon	EPA 8141B	EPA 8141B		
Propachlor (Ramrod)	EPA 8141B	EPA 8141B		
Ronnel		EPA 8141B		
Simazine	EPA 8141B	EPA 8141B		
Stirophos (Tetrachlorovinphos)		EPA 8141B		
Sulfotepp		EPA 8141B		
Thionazin (Zinophos)		EPA 8141B		
Tokuthion (Prothiophos)		EPA 8141B		
Trichloronate		EPA 8141B		
Trifluralin	EPA 8141B	EPA 8141B		
2,4,5-T	EPA 8151A	EPA 8151A		
2,4,5-TP (Silvex)	EPA 8151A	EPA 8151A		
2,4-D	EPA 8151A	EPA 8151A		
2,4-DB	EPA 8151A	EPA 8151A		
4-Nitrophenol	LIAGIJIA	EPA 8151A		
Dalapon	EPA 8151A	EPA 8151A		
Dicamba	EPA 8151A	EPA 8151A		
Dichloroprop	EPA 8151A	EPA 8151A		
Dinoseb	LEAGISIA	EPA 8151A		
MCPA		EPA 8151A		
MCPP				
	EDA 9151 A	EPA 8151A		
Pentachlorophenol	EPA 8151A	EPA 8151A		
1,1,1,2-Tetrachloroethane	EPA 8260B	EPA 8260B		
1 1 1 Trichloroothoro	EPA 8260C	EPA 8260C	TO 15	
1,1,1-Trichloroethane	EPA 8260B	EPA 8260B	TO-15	
1 1 2 2 Totrochloroothono	EPA 8260C	EPA 8260C	TO 15	
1,1,2,2-Tetrachloroethane	EPA 8260B	EPA 8260B	TO-15	***************************************
	EPA 8260C	EPA 8260C		l .

Peter Mhye

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste	Air	Associated Prep
		Soil		Methods
1,1,2-Trichloroethane	EPA 8260B	EPA 8260B	TO-15	
.,.,.	EPA 8260C	EPA 8260C		
1,1,2-Trichloro-1,2,2-	EPA 8260B	EPA 8260B		
Trifluoroethane	EPA 8260C	EPA 8260C		
1,1-Dichloroethane	EPA 8260B	EPA 8260B	TO-15	
i,i Didilidiodilalio	EPA 8260C	EPA 8260C	10 15	
1,1-Dichloroethene (1,1-	EPA 8260B	EPA 8260B	TO-15	
Dichloroethylene)	EPA 8260C	EPA 8260C	10-13	
1,1-Dichloro-2-Propanone	EPA 8260B	EPA 8260B		
1,1-Dicinoro-2-1 Topanone	EPA 8260C	EPA 8260C		
1,1-Dichloropropene	EPA 8260B	EPA 8260B		
1,1-Dicinoropropene	EPA 8260C	EPA 8260C		
1.2.2 Taiablanchannana				
1,2,3-Trichlorobenzene	EPA 8260B	EPA 8260B		42 45 40 40 10 to 40 40
1007:11	EPA 8260C	EPA 8260C	TO 15	
1,2,3-Trichloropropane	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
	EPA 8011			-
1,2,4-Trichlorobenzene	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
1,2,4-Trimethylbenzene	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
1,2-Dibromo-3-Chloropropane	EPA 8260B	EPA 8260B		
(DBCP)	EPA 8260C	EPA 8260C		
	EPA 8011			
1,2-Dibromoethane (EDB)	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
	EPA 8011			
1,2-Dichlorobenzene	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
1,2-Dichloroethane	EPA 8260B	EPA 8260B	TO-15	
•	EPA 8260C	EPA 8260C		
1,2-Dichloroethene	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		
1,2-Dichloropropane	EPA 8260B	EPA 8260B	TO-15	
1,2 2:0:::Oropium	EPA 8260C	EPA 8260C		
1,3,5-Trimethylbenzene	EPA 8260B	EPA 8260B	TO-15	
1,5,5 Illinotily to officere	EPA 8260C	EPA 8260C	1015	
1,3-Dichlorobenzene	EPA 8260B	EPA 8260B	TO-15	
1,3-Dicinorobenzene	EPA 8260C	EPA 8260C	10-15	
1,3-Dichloropropane	EPA 8260B	EPA 8260B		
1,3-Dicinoropropane	EPA 8260B EPA 8260C	EPA 8260B EPA 8260C		
1.2 Diahla	+		TO 15	
1,3-Dichloropropene	EPA 8260B	EPA 8260B	TO-15	
1.4 D'.11	EPA 8260C	EPA 8260C	TOIC	
1,4-Dichlorobenzene	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C	TO 15	
1,4-Dioxane (1,4-	EPA 8260B	EPA 8260B	TO-15	
Diethyleneoxide)	EPA 8260C	EPA 8260C		
1-Chlorobutane	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		
1-Chlorohexane				
1-Ciliofolicadic	EPA 8260B EPA 8260C	EPA 8260B EPA 8260C		

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Parameter / Analyte	Non Potable Water	Solid Hazardous Waste	Air	Associated Prep Methods
1-Propanol	EPA 8260B	EPA 8260B		Menions
r-Propanoi	EPA 8260C	EPA 8260C		
2.2 Diablessesses		·		
2,2-Dichloropropane	EPA 8260B	EPA 8260B		
A.D. A. CATTEL	EPA 8260C	EPA 8260C	TO 15	
2-Butanone (MEK)	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
2-Chloroethylvinylether	EPA 8260B			
	EPA 8260C			
2-Chlorotoluene	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
2-Hexanone (MBK)	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
2-Nitropropane	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		
2-Propanol (Isopropyl Alcohol)	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C	,	
4-Chlorotoluene	EPA 8260B	EPA 8260B		
	EPA 8260C			
4-Isopropyltoluene	EPA 8260B	EPA 8260B	TO-15	
, isopropynous	EPA 8260C	EPA 8260C	1015	
4-Methyl-2-Pentanone (MIBK)	EPA 8260B	EPA 8260B	TO-15	
4-Mediyi-2-i Cittanone (MIBIC)	EPA 8260C	EPA 8260C	10-13	
Acetone	EPA 8260B	EPA 8260B	TO-15	
Accione	EPA 8260C	EPA 8260C	10-13	
Acetonitrile	EPA 8260B	EPA 8260B		
Acetonitine		1		
A1.5.	EPA 8260C	EPA 8260C		
Acrolein	EPA 8260B	EPA 8260B		
A 1 1 11	EPA 8260C	EPA 8260C		
Acrylonitrile	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Allyl Chloride (3-	EPA 8260B	EPA 8260B	TO-15	
Chloropropene)	EPA 8260C	EPA 8260C		
Benzene	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Benzyl Chloride	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Bromobenzene	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		
Bromochloromethane	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		
Bromodichloromethane	EPA 8260B	EPA 8260B	TO-15	
·	EPA 8260C	EPA 8260C		
Bromoform	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Bromomethane	EPA 8260B	EPA 8260B	TO-15	
2. on on on one	EPA 8260C	EPA 8260C	10-13	
Carbon Disulfide	EPA 8260B	EPA 8260B	TO-15	
Carbon Disuillat	EPA 8260C	1	10-12	
Cashan Taturahlarida	+	EPA 8260C	TO 15	
Carbon Tetrachloride	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		

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Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
Chloroacetonitrile	EPA 8260B	EPA 8260B		
CI.I. I	EPA 8260C	EPA 8260C	TO 15	1
Chlorobenzene	EPA 8260B EPA 8260C	EPA 8260B EPA 8260C	TO-15	
Chloroethane (Ethyl Chloride)	EPA 8260B EPA 8260C	EPA 8260B EPA 8260C	TO-15	
Chloroform	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Chloromethane (methyl	EPA 8260B	EPA 8260B	TO-15	
chloride)	EPA 8260C	EPA 8260C		
Chloroprene (2-Chloro-1,3-	EPA 8260B	EPA 8260B		
butadiene)	EPA 8260C	EPA 8260C		
cis-1,2-Dichloroethene (cis-1,2-	EPA 8260B	EPA 8260B	TO-15	
Dichloroethylene)	EPA 8260C	EPA 8260C		
cis-1,3-Dichloropropene	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Cyclohexane	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Dibromochloromethane	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Dibromomethane	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		
Dichlorodifluoromethane	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Dichlorofluoromethane	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		
Diethyl Ether	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		
Diisobutylene (2,4,4-Trimethyl-	EPA 8260B	EPA 8260B		
1-pentene)	EPA 8260C	EPA 8260C		
Diisopropyl Ether (Propane)	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Ethyl Acetate	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Ethyl Benzene	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Ethyl Methacrylate	EPA 8260B	EPA 8260B		
-	EPA 8260C	EPA 8260C		
Ethyl-tert-butylether (ETBE)	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Heptane	EPA 8260B	EPA 8260B	TO-15	
•	EPA 8260C	EPA 8260C		
Hexachlorobutadiene	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Hexachloroethane	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		
Hexane	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Iodomethane (Methyl Iodide)	EPA 8260B	EPA 8260B		
(EPA 8260C	EPA 8260C		
				1

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Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
Isobutyl Alcohol (2 Methyl-1-	EPA 8260B	EPA 8260B		
Propanol)	EPA 8260C	EPA 8260C		
Isopropylbenzene (Cumene)	EPA 8260B	EPA 8260B	TO-15	
,	EPA 8260C	EPA 8260C		
Methacrylonitrile	EPA 8260B	EPA 8260B		
•	EPA 8260C	EPA 8260C		
Methyl Acetate	EPA 8260B	EPA 8260B		
•	EPA 8260C	EPA 8260C		
Methyl Acrylate	EPA 8260B	EPA 8260B		
•	EPA 8260C	EPA 8260C		
Methylcyclohexane	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		
Methylene Chloride	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Methyl Methacrylate	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		
Methyl-tert-butylether (MTBE)	EPA 8260B	EPA 8260B	TO-15	
, , , , , , , , , , , , , , , , , , , ,	EPA 8260C	EPA 8260C		
m + p Xylene (1,3+1,4 Xylene)	EPA 8260B	EPA 8260B	TO-15	
p	EPA 8260C	EPA 8260C		
Naphthalene	EPA 8260B	EPA 8260B	TO-15	
- vap	EPA 8260C	EPA 8260C		
n-Butylbenzene	EPA 8260B	EPA 8260B		
n Buly is simone	EPA 8260C	EPA 8260C		
Nitrobenzene	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
n-Propylbenzene	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Octane	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		
o-Xylene (1,2-Xylene)	EPA 8260B	EPA 8260B	TO-15	
0 11510110 (1,2 11510110)	EPA 8260C	EPA 8260C	••••	
Pentachloroethane	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		
Pentane	EPA 8260B	EPA 8260B		
Telitane	EPA 8260C	EPA 8260C		
Propionitrile (Ethyl Cyanide)	EPA 8260B	EPA 8260B		
Tropiolitine (Ethyl Cyamide)	EPA 8260C	EPA 8260C		
sec-Butylbenzene	EPA 8260B	EPA 8260B		
Sec-Duty localization	EPA 8260C	EPA 8260C		
Stamono	EPA 8260B	EPA 8260B	TO-15	
Styrene	EPA 8260C	EPA 8260C	10-12	
tert-Amyl Methyl Ether (TAME)	EPA 8260B	EPA 8260B	TO-15	
terr-winyr Methyr Ether (TAIME)	EPA 8260C	EPA 8260C	10-13	
tant Amul athul Ethan	+		1	
tert-Amyl ethyl Ether	EPA 8260B	EPA 8260B		
And And Alaskal (2)	EPA 8260C	EPA 8260C		
tert-Amyl Alcohol (2-methyl-2-	EPA 8260B	EPA 8260B		
but)	EPA 8260C	EPA 8260C		
tert-Butylbenzene	EPA 8260B	EPA 8260B		
	EPA 8260C	EPA 8260C		

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Parameter / Analyte	Non Potable Water	Solid Hazardous Waste	Air	Associated Prep
test Dutyl Aleghal	EPA 8260B	EPA 8260B	TO 15	Methods
tert-Butyl Alcohol	EPA 8260B	EPA 8260C	TO-15	
Tetrachloroethene	EPA 8260B	EPA 8260B	TO-15	
1 ditadifior definence	EPA 8260C	EPA 8260C	10-15	
Tetrahydrofuran (THF)	EPA 8260B	EPA 8260B	TO-15	
Tollariya oralari (TTII)	EPA 8260C	EPA 8260C	10-15	
Toluene	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C	10.5	
trans-1,2-Dichloroethene (trans-	EPA 8260B	EPA 8260B	TO-15	
1,2-Dichloroethylene)	EPA 8260C	EPA 8260C		
trans 1,3-Dichloropropene	EPA 8260B	EPA 8260B	TO-15	
P. P.	EPA 8260C	EPA 8260C		
trans 1,4-Dichloro-2-butene	EPA 8260B	EPA 8260B		
.,	EPA 8260C	EPA 8260C		
Trichloroethene	EPA 8260B	EPA 8260B	TO-15	
(Trichloroethylene)	EPA 8260C	EPA 8260C		
Trichlorofluoromethane	EPA 8260B	EPA 8260B	TO-15	
	EPA 8260C	EPA 8260C		
Vinyl Acetate	EPA 8260B	EPA 8260B	TO-15	
•	EPA 8260C	EPA 8260C		
Vinyl Chloride	EPA 8260B	EPA 8260B	TO-15	
-	EPA 8260C	EPA 8260C		
Xylenes-Total	EPA 8260B	EPA 8260B	TO-15	
•	EPA 8260C	EPA 8260C		
Methane, Ethane and Ethene	RSK 175			
1,2,4,5-Tetrachlorobenzene	EPA 8270D	EPA 8270D		
2,3,4,6-Tetrachlorophenol	EPA 8270D	EPA 8270D		
2,3,5,6-Tetrachlorophenol	EPA 8270D	EPA 8270D		
1,2,4-Trichlorobenzene	EPA 8270D	EPA 8270D		
1,2-Dichlorobenzene	EPA 8270D	EPA 8270D		
1,2-Dinitrobenzene	EPA 8270D	EPA 8270D		
1,2-Diphenylhydrazine	EPA 8270D	EPA 8270D		
1,3-Dichlorobenzene	EPA 8270D	EPA 8270D		
1,3-Dinitrobenzene (1,3-DNB)	EPA 8270D	EPA 8270D		
1,4-Dichlorobenzene	EPA 8270D	EPA 8270D		
1,4-Dinitrobenzene	EPA 8270D	EPA 8270D		
1,4-Dioxane (1,4-	EPA 8270D	EPA 8270D		
Diethyleneoxide)				
2,4,5-Trichlorophenol	EPA 8270D	EPA 8270D		
2,4,6-Trichlorophenol	EPA 8270D	EPA 8270D		
2,3-Dichloroaniline	EPA 8270D	EPA 8270D		
2,4-Dichlorophenol	EPA 8270D	EPA 8270D		
2,4-Dimethylphenol	EPA 8270D	EPA 8270D		
2,4-Dinitrophenol	EPA 8270D	EPA 8270D		
2,4-Dinitrotoluene (2,4-DNT)	EPA 8270D	EPA 8270D		
`,'	EPA 8270D SIM			
2,6-Dichlorophenol	EPA 8270D	EPA 8270D		
2,6-Dinitrotoluene (2,6-DNT)	EPA 8270D	EPA 8270D		
	1			
	EPA 8270D SIM			
2-Chloronaphthalene	EPA 8270D SIM	EPA 8270D		

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste	Air	Associated Prep Methods
2-Methylnaphthalene	EPA 8270D EPA 8270D SIM	EPA 8270D EPA 8270D SIM		
2-Methylphenol	EPA 8270D	EPA 8270D		
2-Naphthylamine	EPA 8270D	EPA 8270D		
2-Nitroaniline	EPA 8270D	EPA 8270D		
2-Nitrophenol	EPA 8270D	EPA 8270D		
3-3'-Dichlorobenzidine	EPA 8270D	EPA 8270D		
3-Methylphenol	EPA 8270D	EPA 8270D		******
3-Nitroaniline	EPA 8270D	EPA 8270D		
3&4-Methylphenol	EPA 8270D	EPA 8270D		
4,6-Dinitro-2-Methylphenol (2-	EPA 8270D	EPA 8270D		
Methyl-4,6-dinitrophenol)				
4-Bromophenyl-Phenyl Ether	EPA 8270D	EPA 8270D		*******
4-Chloroaniline	EPA 8270D	EPA 8270D		
4-Chloro-3-Methylphenol	EPA 8270D	EPA 8270D		
4-Chlorophenyl-Phenyl Ether	EPA 8270D	EPA 8270D		
1-Methylnaphthalene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		
4-Methylphenol (p-Cresol)	EPA 8270D	EPA 8270D		
4-Nitroaniline	EPA 8270D	EPA 8270D		
4-Nitrophenol	EPA 8270D	EPA 8270D		
1,1-Biphenyl	EPA 8270D	EPA 8270D		
Acenaphthene	EPA 8270D	EPA 8270D		
1 tooliapittiono	EPA 8270D SIM	EPA 8270D SIM		
Acenaphthylene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		
Acetophenone	EPA 8270D	EPA 8270D		
Alpha-Terpineol	EPA 8270D	EPA 8270D		*********
Aniline	EPA 8270D	EPA 8270D		
Anthracene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		
Atrazine	EPA 8270D	EPA 8270D		
Azobenzene	EPA 8270D	EPA 8270D		
Benzidine	EPA 8270D			
Benzaldehyde	EPA 8270D	EPA 8270D		
Benzo(a)Anthracene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		
Benzo(a)Pyrene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		
Benzo(b)Fluoranthene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		
Benzo(ghi)Perylene	EPA 8270D	EPA 8270D		~~~~~
	EPA 8270D SIM	EPA 8270D SIM		
Benzo(k)Fluoranthene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		
Benzoic Acid		EPA 8270D		
Benzyl Alcohol	EPA 8270D	EPA 8270D		*******
Bis(2-Chloroethyl) Ether	EPA 8270D	EPA 8270D		
Bis(2-Chloroethoxy) Ether	EPA 8270D	EPA 8270D		
Bis(2-Chloroethoxy) Methane	EPA 8270D	EPA 8270D		
		DI A GETOD		<u> </u>

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Parameter / Analyte	Non Potable Water	Solid Hazardous Waste	Air	Associated Prep Methods
Bis(2-Chloroisopropyl) Ether	EPA 8270D	EPA 8270D		
Bis(2-Ethylhexyl) Adipate	EPA 8270D	EPA 8270D		
Bis(2-Ethylhexyl) Phthalate(DEHP)	EPA 8270D	EPA 8270D		
Butyl Benzyl Phthalate	EPA 8270D	EPA 8270D		
Carbazole	EPA 8270D	EPA 8270D		
Caprolactam	EPA 8270D	EPA 8270D		
Chrysene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		
Dibenzo(a,h)Anthracene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		
Dibenzofuran	EPA 8270D	EPA 8270D		
Diethyl Phthalate	EPA 8270D	EPA 8270D		
Dimethoate	EPA 8270D	EPA 8270D		
Dimethyl Phthalate	EPA 8270D	EPA 8270D		
Di-n-Butyl Phthalate	EPA 8270D	EPA 8270D		
Di-n-Octyl Phthalate	EPA 8270D	EPA 8270D		
Dioxin Screen (2,3,7,8-TCDD)	EPA 8270D	EPA 8270D		
Diphenylamine	EPA 8270D	EPA 8270D		
Fluoranthene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		
Fluorene	EPA 8270D	EPA 8270D		*******
	EPA 8270D SIM	EPA 8270D SIM		
Hexachlorobenzene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		
Hexachlorobutadiene	EPA 8270D	EPA 8270D		
Hexachlorocyclopentadiene	EPA 8270D	EPA 8270D		
Hexachlorethane	EPA 8270D	EPA 8270D		
Indeno (1,2,3-CD) Pyrene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		
Isophorone	EPA 8270D	EPA 8270D		
Naphthalene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		
Nitrobenzene	EPA 8270D	EPA 8270D		
n-Decane	EPA 8270D	EPA 8270D		*******
n-Heptadecane	EPA 8270D	EPA 8270D		
n-Octadecane	EPA 8270D	EPA 8270D		
n-Nitrosodiethylamine	EPA 8270D	EPA 8270D		
n-Nitrosodimethylamine	EPA 8270D	EPA 8270D		•••••
n-Nitrosodiphenylamine	EPA 8270D	EPA 8270D		
n-Nitroso-di-n-Butylamine	EPA 8270D	EPA 8270D		
n-Nitrosodi-n-Propylamine	EPA 8270D	EPA 8270D		
n-Nitrosopyrrolidine	EPA 8270D	EPA 8270D		
Pentachlorobenzene	EPA 8270D	EPA 8270D		
Pentachlorophenol	EPA 8270D	EPA 8270D		
Phenanthrene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM	<u> </u>	
Phenol	EPA 8270D	EPA 8270D		
Pyrene	EPA 8270D	EPA 8270D		
	EPA 8270D SIM	EPA 8270D SIM		

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Parameter / Analyte	Non Potable Water	Solid Hazardous Waste	Air	Associated Prep
75 111	ED + 0050D	Soil	-	Methods
Pyridine	EPA 8270D	EPA 8270D		
Resorcinol	EPA 8270D	EPA 8270D		
1,3-Dinitrobenzene (1,3-DNB)	EPA 8330B	EPA 8330B		
1,3,5-Trinitrobenzene (1,3,5-TNB)	EPA 8330B	EPA 8330B		
2,4,6-Trinitrotoluene (2,4,6-	EPA 8330B	EPA 8330B		
TNT)				
2,4-Dinitrotoluene (2,4-DNT)	EPA 8330B	EPA 8330B		*******
2,6-Dinitrotoluene (2,6-DNT)	EPA 8330B	EPA 8330B		
2-Amino-4,6-Dinitrotoluene	EPA 8330B	EPA 8330B		
3,5-Dinitroaniline	EPA 8330B	EPA 8330B		
Nitrobenzene	EPA 8330B	EPA 8330B		
Nitroglycerin	EPA 8330B	EPA 8330B		
Nitroguanidine	USACE-89-35	USACE-89-35		
2-Nitrotoluene	EPA 8330B	EPA 8330B		
3-Nitrotoluene	EPA 8330B	EPA 8330B	†	
4-Amino-2,6-Dinitrotoluene	EPA 8330B	EPA 8330B	1	
4-Nitrotoluene	EPA 8330B	EPA 8330B		
HMX	EPA 8330B	EPA 8330B	+	
RDX	EPA 8330B	EPA 8330B		
Tetryl PETN	EPA 8330B	EPA 8330B		
	EPA 8330B	EPA 8330B	TO 15	
1,2,3-Trimethylbenzene			TO-15	
1,2-Dichlorotetrafluoroethane (Freon 114)		***************************************	TO-15	
1,3-Hexachlorobutadiene		***********	TO-15	
2,2,4-Trimethylpentane (Isooctane)			TO-15	
4-Ethyltoluene			TO-15	*********
n-Heptane		******	TO-15	
n-Hexane			TO-15	
Butadiene (1,3-)			TO-15	
Propylene			TO-15	
Trichloro (1,1,2) Trifluoroethane (1,2,2)			TO-15	*******
Vinyl Bromide			TO-15	
Xylene (m)	***************************************		TO-15	
Xylene (n)			TO-15	
Xylene (p)			TO-15	
лунене (p)		440000000000000000000000000000000000000	10-13	
Hazardous Waste Characteristics				
Ignitability				EPA 1030
Flashpoint		***************************************		EPA 1010A
Toxicity Characteristic Leaching Procedure				EPA 1311
Synthetic Precipitation Leaching Procedure				EPA 1312

Peter Mhyu Page 13 of 13



CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board

500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

ALS Environmental – Salt Lake City 960 West LeVoy Drive Salt Lake City, UT 84123

has been assessed by ANAB and meets the requirements of

ISO/IEC 17025:2005 and DoD-ELAP

while demonstrating technical competence in the field(s) of

TESTING

Refer to the accompanying Scope(s) of Accreditation for information regarding the types of tests to which this accreditation applies.

ADE - 1420

Certificate Number

ANAB Approval

Certificate Valid To: 11/25/2017

Version No. 002 Issued: 10/23/2015





SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005 & DoD-ELAP

ALS Environmental – Salt Lake City

960 West LeVoy Drive, Salt Lake City, UT 84123 Robert P. Di Rienzo Phone: 801-266-7700 Bob.DiRienzo@ALSGlobal.com www.datachem.com

TESTING

Valid to: November 25, 2017 Certificate Number: ADE- 1420

I. Chemical

MATRIX	SPECIFIC TEST or GROUP OF ANALYTES**	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY USED
Dietary Supplements	Dietary Supplements and Residues	DS-OR-LC-UV-MS, USP	HPLC LC-MS
Dietary Supplements	Dietary Supplements and Residues	DS-OR-GCMS-SVOL, USP	GC-MS
Dietary Supplements	Elements and Metals Residues	DS-IN-ICP, DS-IN-ICP-MS, USP	ICP ICP-MS
Dietary Supplements	Dietary Supplements and Residues	DS-OR-IC, USP	IC
Dietary Supplements	Mercury Residues	DS-IN-HG, USP	CVAA
Toys, Lead Paint	Lead	IN AN 021/3050 6010C	ICP
CPSC - CH - E1003 - 09.1 Toys Lead Paint	Lead	IN AN 021/3050 6010C	ICP
CPSC-CH-C1001-09.3 Phthalates in Toys	Phthalates	OE-SW-3550, OS-SW-8270D – Appendix D	GC/MS
CPSC-CH-C1001-09.3 Phthalates in Plastic and Packaging	Phthalates	OE-SW-3550, OS-SW-8270D – Appendix D	GC/MS

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500 Montgomery St. Suite 625 | Alexandria, VA 22314 | 703-836-0025 | www.anab.org



MATRIX	SPECIFIC TEST or GROUP OF ANALYTES**	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY USED
Children's Metal Jewelry, (CPSC Test Method CPSC- CH-E1001-08 for Determining Total Lead)	MMDITES	(an El 74 unicss specifica)	USED
Children's Metal Products, (CPSC Test Method CPSC- CH-E1001-08 for Determining Total Lead in Children's Metal Products)	Lead	IN AN 021/3050 6010C	ICP
Non-Metal Children's Products, (CPSC Test Method CPSC-CH-E1002-08 Standard Operating Procedure for Determining Total Lead (Pb) in Non-Metal Children's Products)			

II. Environmental

MATRIX	SPECIFIC TEST or GROUP OF ANALYTES**	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY USED
Water / Solid & Hazardous Waste	Volatiles	8260 5030	GC/MS Purge and Trap
Water / Solid & Hazardous Waste	Pesticides	8081	GC/ECD
Water / Solid & Hazardous Waste	PCBs	8082	GC/ECD
Water / Solid & Hazardous Waste	Herbicides	8151	GC/ECD
Water / Solid & Hazardous Waste	Semivolatiles	8270	GC/MS
Water / Solid & Hazardous Waste	Diesel Range Organics	8015	GC/FID
Water / Solid & Hazardous Waste	Residual Range Organics	8015	GC/FID
Solid & Hazardous Waste	GPC	3640	GPC





MATRIX	SPECIFIC TEST or GROUP OF ANALYTES**	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY USED
Water / Solid & Hazardous Waste	Volatiles Prep	5035	Closed System Purge and Trap
Water / Solid & Hazardous Waste	TCLP	1311	Leaching Procedure
Water / Solid & Hazardous Waste	SPLP	1312	Leaching Procedure
Water / Solid & Hazardous Waste	Anions	9056	IC
Water / Solid & Hazardous Waste	Hexavalent Chromium	7196	UV/VIS
Water / Solid & Hazardous Waste	Sulfide	9030 9034	Titration
Water / Solid & Hazardous Waste	рН	9040 9045	pH Meter
Water / Solid & Hazardous Waste	Total Cyanide	9012	UV/VIS
Water / Solid & Hazardous Waste	Metals	6010	ICP
Water / Solid & Hazardous Waste	Metals	6020	ICP/MS
Water / Solid & Hazardous Waste	Mercury	7470 7471	CVAA
Water	Metals Prep	3010	Hot Block
Solid & Hazardous Waste	Metals Prep	3050	Hot Block
Water	Explosives	8330B	LC/UV or LC/MS/MS
Solid & Hazardous Waste	Explosives	8330B1	LC/UV or LC/MS/MS
Water	Organics Prep	3510	Liquid/Liquid Extraction

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MATRIX	SPECIFIC TEST or GROUP OF ANALYTES**	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY USED
Solid & Hazardous Waste	Organics Prep	3550	Sonic Disruptor
Solid & Hazardous Waste	Organics Prep	3580	Waste Dilution
Water / Solid & Hazardous Waste	Agent Degradation Products	LC-MS-AgentDegs**	LC/MS
Water / Solid & Hazardous Waste	Agent Degradation Products	OS-SW-8270D Appendix B, OE-SW-3510, OE-SW-3550**	GC/MS
Water / Solid & Hazardous Waste	Perchlorate	6850**	LC/MS
Water / Solid & Hazardous Waste	White Phosphorus	7580**	GC/FPD
Air	Volatiles	TO-15	GC/MS

Notes:

- 1. * = As Applicable
- 2. ** = These tests are accredited to the requirements of the DoD Environmental Laboratory Accreditation Program as defined in the DoD QSM V5.0. Refer to Accredited Analyte Listing for specific analytes in which the laboratory is accredited
- 3. ¹ = Does not perform Incremental Sampling Methods
- 4. This scope is formatted as part of a single document including the Certificate of Accreditation No. ADE- 1420





	DoD ELAP Accredited Analytes/Methods (by matrix)								
	ALS Environmental Salt Lake City, Utah								
NELAC Code	Analyte								
		Non-Potable Water	Soil and Chemica	al Waste Air					
	Misc Analytes								
1895	Perchlorate	6850	6850						
	White Phosphorus	7580	7580						
	GC/MS Agent Degradation Products								
9546	1,4-Dithiane	8270/3510	8270/3550						
9551	1,4-Oxathiane	8270/3510	8270/3550						
	LC/MS Agent Degradation Products								
	Fluoroacetic Acid	In House LC/MS	In House LC/MS						
	Chloroacetic Acid	In House LC/MS	In House LC/MS						
	Methyl Phosphonic Acid (MPA)	In House LC/MS	In House LC/MS						
	Ethyl Methyl Phosphonic Acid (EMPA)	In House LC/MS	In House LC/MS						
	Isopropyl Methyl Phosphonic Acid (IMPA)	In House LC/MS	In House LC/MS						
	Thiodiglycol	In House LC/MS	In House LC/MS						
	Dimethyl methyl Phosphonate (DMMP)	In House LC/MS	In House LC/MS						
	Diisopropyl methyl Phosphonate (DIMP)	In House LC/MS	In House LC/MS						